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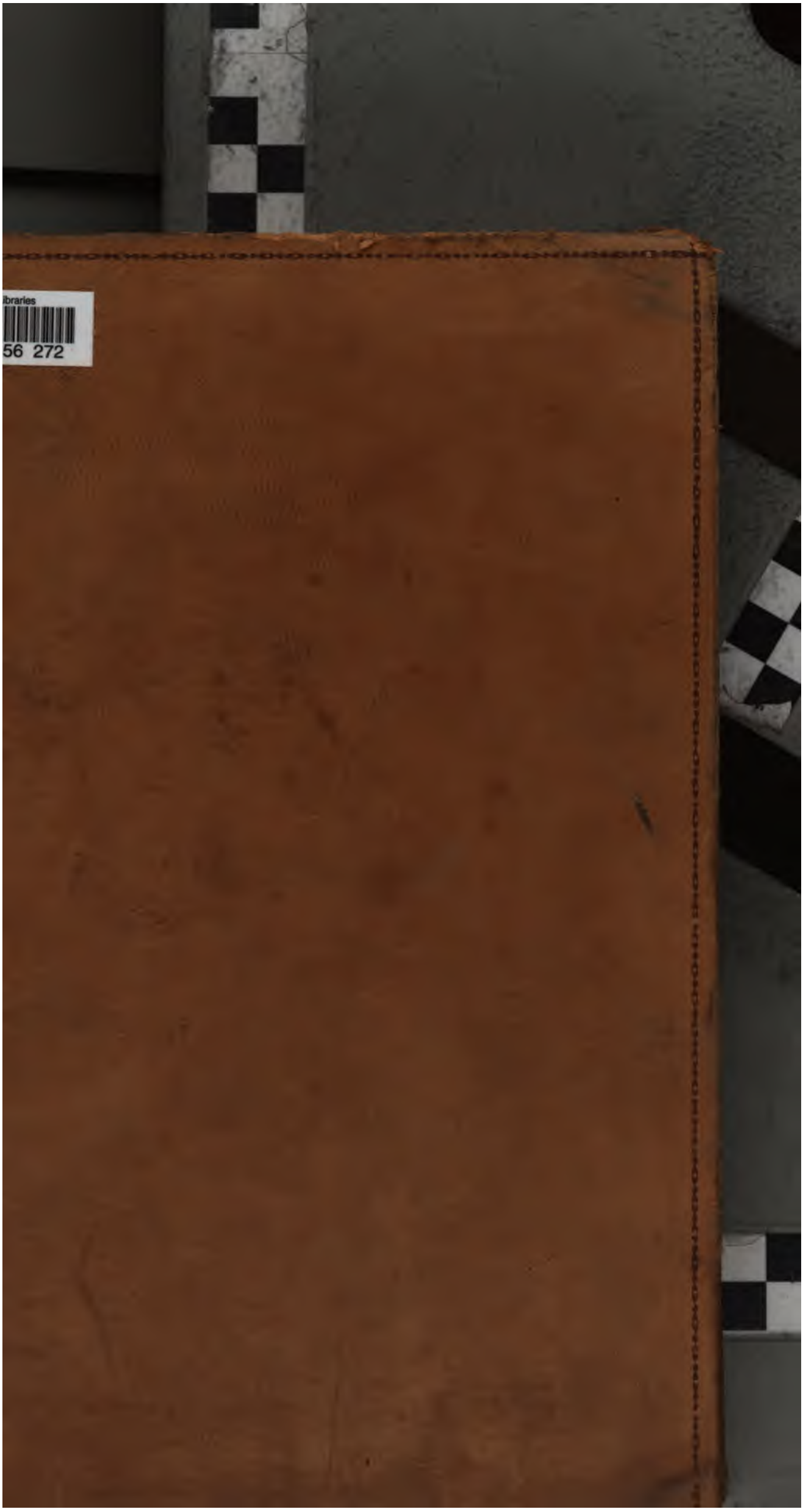
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# 1.—THE FISHES OF THE KLAMATH BASIN.

By CHARLES H. GILBERT, Ph. D.,

*Professor of Zoology, Leland Stanford Junior University.*

The Klamath River rises in the arid region east of the Cascade Mountains in south-central Oregon. After expanding to form the Klamath Lakes, it cuts its way through the mountainous region of northern California and enters the sea nearly midway between the mouths of the Columbia and Sacramento rivers. It occupies, therefore, an intermediate and closely contiguous position with respect to these two great river systems, being separated from them in many places by narrow watersheds only. It is the more remarkable that its fish-fauna should contain nothing in common with either of them, save such anadromous forms as the salmon, trout, sturgeon, and lamprey, which enter all the rivers of the coast. Such characteristic genera as *Mylocheilus*, *Acrocheilus*, and *Columbia*, of the Columbia River, and *Mylopharodon*, *Pogonichthys*, *Orthodon*, *Lavinia*, *Archoplites*, and *Hysterocarpus*, of the Sacramento, have no representatives in the Klamath. Even the genus *Ptychocheilus* is unrepresented there, though present in both the Sacramento and the Columbia, where *P. grandis* and *P. oregonensis* are but slightly different and are among the most abundant and characteristic fishes of their respective basins. A similar case is that of *Cottus asper* of the Columbia and *Cottus gulosus* of the Sacramento, two species so extremely similar that it is difficult to distinguish them, yet without any close relative in the Klamath.

The relations of the Klamath fishes become at once apparent, however, when we compare them with those of the Lahontan and Bonneville basins of Nevada and Utah.* In each of these three localities the same genera occur—among them *Chasmistes*, which is not found elsewhere—and in many cases their species are so close as to be undoubtedly representative. That the three areas have at one time formed part of the same hydrographic basin can not be questioned. Nor can we doubt that they have been separated for a very long period—long enough to permit the complete differentiation of every species within each of them—for no species is now known to be common to any two of them, if we exclude the whitefish and perhaps the trout, two forms which seem to be superior to any discoverable law of distribution.

The Lahontan Basin has been very imperfectly explored, but the facts now at hand do not warrant the assumption that it has maintained a connection with the Klamath at any time since its final separation from the Bonneville. Future exploration may be expected to throw light on this question. Important, also, will be a thorough survey of the lakes of southeastern Oregon which lie between the Lahontan and Klamath basins. Cope's investigation of these leaves much to be desired, and no facts are as

* See Cope, "On the Fishes of the Recent and Pliocene Lakes of the western part of the Great Basin, and of the Idaho Pliocene Lake." Proc. Acad. Nat. Sci. Phila. 1883, pp. 134–167.

yet available from which we can draw conclusions as to their interrelationships and recent history. Excluding anadromous fishes and the trout, the Klamath is known to contain eleven species, of which eight are peculiar to this basin, two (*Catostomus snyderi* and *Rutilus bicolor*) have been reported as well from Goose Lake, its neighbor on the east, and one species (*Catostomus oregonus*) seems to occur also in Rogue River, its neighbor on the north.

The collection here reported on was made at Klamath Falls, Oregon, in the interests of the United States Fish Commission, June 13–16, 1894, by the writer, assisted by Frank Cramer and Keinosuke Otaki. Collecting was carried on near the outlet of the Upper Lake, in the river at and below Klamath Falls, and in Lost River below Lostine. A few specimens were also secured in Willow Creek, at Ager, California. Valuable for comparison have been a few fishes collected in Scott River, Siskiyou County, California, by Mr. R. C. McGregor, and in Trinity River, Hoopa Valley, California, by Capt. W. E. Dougherty.

The lower part of Upper Klamath Lake is narrow, and is surrounded by a marginal tule belt, which is overflowed at high water. The bottom consists of mud and sand, with scattered lava bowlders. The outlet is a very rapid, turbulent stream, 50 to 75 feet wide, and falling about 85 feet between the lake and the town of Klamath Falls. It swirls around huge lava bowlders and makes imposing rapids. The temperature of the water June 13, at 9 a. m., was 56°; temperature of air, 64°. At Klamath Falls the river widens out, covering at the time of our visit extensive bottom lands, partly in tules, partly meadows. From this portion a slough makes off toward Lost River, into which it carries a considerable amount of water during early summer. Tule Lake and Lower Klamath Lake are overflow reservoirs from Klamath River, and lie lower than that stream.

At the time of our visit the lake and river contained many dead and dying fish, principally Catostomoids. *Chasmistes stomias* seemed to predominate, then *Deltistes luxatus*, *Chasmistes brevirostris*, and *Catostomus snyderi*, in the order given. The breeding season for these fish is said to be in March and April, varying from year to year with the condition of the streams. We saw no specimens entirely free from injury. Many had lost a portion of their fins, some had round holes in their sides, said to be caused by lampreys; many had diseased areas covered by a fungous growth, and a large number were afflicted by some disease of the skin of the head, which turned yellow and flaked off, leaving the skull bare. This disease often attacked and destroyed the eyes. We were told that the same fish in Tule Lake were never diseased. A few large specimens of *Rutilus bicolor* were also attacked, but other fish seemed not to be affected.

## LIST OF SPECIES.

**1. Entosphenus tridentatus** (Gairdner).

One young specimen of this anadromous species, 26 cm. long, was taken in Klamath. They are said to be abundant in the lake, and to attack fishes, which are often seen to leap out of the water to free themselves. Several of the mutilated suckers which were examined had round wounds on their bodies, which might well have been produced by the lamprey. It is not improbable that this species has become resident in Upper Klamath Lake, as happens with other anadromous species elsewhere.

**2. Acipenser medirostris** Ayres.

A young specimen of the green sturgeon is in the museum of Stanford University, collected in Trinity River, Hoopa Valley, California, by Capt. W. E. Dougherty. The species was not seen at Upper Klamath Lake.

**3. Catostomus rimiculus** Gilbert & Snyder, new species.

? *Catostomus tahoensis* Cope, Proc. Ac. Nat. Sci. Phila. 1883, 152; Warner Lake.

This species belongs to the *C. catostomus* type, with very small scales, and is most nearly related to *C. tahoensis*. From the latter it differs in the smaller eye, less deeply cleft lower lip, blunter labial tubercles, larger scales, and the much smaller fontanelle, which is reduced in adults to a very narrow linear slit, or more commonly entirely obsolete.

Type No. 5654, Leland Stanford Junior University collection. Type locality, Trinity River, Hoopa Valley, Humboldt County, California. Collector, Capt. W. E. Dougherty. Additional specimens were collected in Scott River (Klamath Basin), Siskiyou County, California, by R. C. McGregor.

Head 4⅛ in body; depth 5; depth of caudal peduncle 2¾ in head; eye 7½; dorsal rays 11; anal rays 7; scales in lateral line 91; above lateral line 18; from lateral line to insertion of ventral 13; before dorsal 42. Dorsal 11. Anal 7. Pectorals 17.

Head as deep as wide. Both lips full, the lobe of lower lip broadly rounded behind, the cleft not nearly reaching base of lip; the portion between mandible and apex of cleft with four series of tubercles; tubercles coarse and blunt, becoming reduced in size toward margins of lips, but less so than in related species; upper lip with five rows of tubercles. Eyes very small, the front of the eye nearly midway of head. Interorbital space convex, 2¾ in head.

Scales comparatively smooth, gradually growing smaller posteriorly.

Dorsal fin inserted midway between end of snout and base of caudal; first ray preceded by two short, simple ones; last ray divided to base; length of base of fin equal to the height, which is contained 6½ times in the body. Height of anal twice the length of the base; contained 5 times in body; length of pectorals 4¾ in body; ventrals 6¼ in body; caudal 4¼.

Color above dusky, the central parts of scales lighter; under parts white; dorsal and caudal fins dusky, others white.

The total length of the type is 266 millimeters.

In the following table the scales above the lateral line were counted from the lateral line upward and forward to a point half way between the dorsal fin and occiput; below the lateral line, downward and backward to insertion of ventral.

| | Number of scales in lateral line. | Number of scales above lateral line. | Number of scales below lateral line. | Number of scales before dorsal. | Number of dorsal rays. | Number of anal rays. |
|---|---|---|---|---|---|---|
| Two specimens from Trinity River, Hoopa Valley, Cal., Capt. W. E. Dougherty, collector. | 91 | 18 | 13 | 42 | 11 | 7 |
| | 81 | 15 | 12 | 41 | 11 | 7 |
| Four specimens from Scott River, Siskiyou County, Cal., R. C. McGregor, collector. | 85 | 18 | 12 | 41 | 11 | 7 |
| | 84 | 15 | 12 | 42 | 11 | 7 |
| | 88 | 15 | 11 | 42 | 11 | 7 |
| | 89 | 14 | 11 | 43 | 11 | 7 |

**4. Catostomus snyderi,** new species.

*Catostomus labiatus* Girard, Proc. Ac. Nat. Sci. Phila. 1856, 175; and of all recent authors. Not *Catostomus labiatus* Ayres, Proc. Calif. Ac. Nat. Sci. 1855, 32, from Stockton, California, and synonymous with *C. occidentalis* Ayres.

Type, No. 48222, U. S. N. M. Type locality, Upper Klamath Lake, Oregon. Collectors: Gilbert, Cramer, and Otaki.

Closely related to *C. occidentalis* and *C. macrocheilus*, differing from both species in the shorter head, smaller mouth and lips, deeper caudal peduncle, somewhat smaller scales, and in the shorter dorsal fin, which is more anteriorly inserted.

Head 4¼ in length; snout $2\frac{3}{10}$ in head, equaling interorbital width; eye 5¼; D. 11; A. 7; scales 69 to 77; above the lateral line, 13 or 14; below the lateral line, 10 or 11. Mouth very small, the width between angles but half length of snout in our largest specimen; greatest width of lobe of lower lip two-thirds diameter of eye; lower lip deeply incised, with one or two papillæ between symphysis and base of cleft; upper lip narrow, with five or six papillæ in a cross series, the uppermost becoming very small; basal portion of the lower lip with coarse tubercles, those toward posterior margin becoming very fine and arranged in evident series separated by grooves. Mucous canals on head forming conspicuous raised ridges with prominent pores, the system much more conspicuously developed than in any related species. Origin of dorsal fin constantly nearer snout than base of caudal; the dorsal fin short, its base not exceeding the height of the longest ray, usually less. In our specimens the

pectorals reach scarcely two-thirds distance to ventrals and the ventrals scarcely two-thirds distance to vent. The anal may extend beyond base of rudimentary caudal rays.

Scales strongly ridged, their margins crenate; the anterior scales are smaller, but do not appear greatly crowded; the average number of tubes in the lateral line is about 73, the number varying from 69 to 77. There are 13 or 14 in an oblique series from middle of back downward and backward to lateral line, and 10 or 11 between lateral line and base of ventrals.

Dusky, the lower part of sides with coarse black specks, the under parts white. Fins all dusky.

In the following table of measurements the unit is one hundredth of the length from tip of snout to base of median caudal rays. The length of caudal peduncle is taken from base of last anal ray to the vertical from base of median caudal rays:

| Measurements. | No. 1. | No. 2. | No. 3. | No. 4. |
|---|---|---|---|---|
| Total length in millimeters | 238 | 205 | 153 | 139 |
| Length of head | 23 | 23 | 23 | 23 |
| Length of snout | 11 | 10 | 10 | 10 |
| Diameter of eye | 4 | 4 | 4 | 5 |
| Length of mandible | 6½ | 7 | 7½ | 7 |
| Interorbital width | 10 | 9½ | 9½ | 10 |
| Depth at occiput | 18 | 17 | 17½ | 18 |
| Depth of caudal peduncle | 9½ | 9 | 9½ | 9½ |
| Length of caudal peduncle | 16½ | 16½ | 16 | 18 |
| Distance from snout to origin of dorsal | 49 | 49 | 48½ | 49 |
| Distance from snout to insertion of ventrals | 55 | 55 | 54½ | 54 |
| Height of dorsal | 16½ | 16½ | 17 | 18 |
| Base of dorsal | 16½ | 14 | 17 | 15½ |

In 13 specimens the fully developed dorsal rays are 11, 11, 11, 11, 11, 11, 11, 11, 11, 11, 12, 12, 12. All have 7 anal rays. In 11 specimens the oblique rows of scales above lateral line are 70, 71, 73, 73, 75, 75, 75, 75, 76, 77, 77.

A few specimens, none of them adult, were taken in Upper Klamath Lake and in Lost River. The species is named for my assistant and coworker, Mr. John O. Snyder, who first noticed that *Catostomus labiatus* was a synonym of *C. occidentalis*, and that the present species was unnamed.

**5. Chasmistes brevirostris** Cope.

Two species of typical *Chasmistes* inhabit Upper Klamath Lake, so similar in all their characters that it is difficult to decide to which one the name *brevirostris* properly belongs. The scale and fin formulæ are the same, and the general proportions scarcely differ. One of them has a larger, deeper head, with larger, more obliquely placed mouth, and conspicuously protruding premaxillary spines. To the other, with smooth upper profile of snout and smaller, more nearly horizontal mouth, I here apply the name *brevirostris*, following Cope's assertion that the snout "is without the hump produced by the protuberant premaxillary spines." In all other respects Cope's brief description applies equally well to both species; but the one described below as new, under the name *C. stomias*, is apparently the most abundant in the lake, and is known to the Indians by the name attributed by Cope to *C. brevirostris*.

One adult and several young specimens of *C. brevirostris* were preserved; others were seen, but were so mutilated as to be unfit for preservation. From this adult, a female 37 cm. long, the following notes are taken:

Mouth inclined at an angle of about 15°. Maxillary reaching a vertical from slightly behind front of nostrils, its length contained 1⅓ times in snout. Mandible 1¼ in snout. Lips thin, the lower interrupted at symphysis, forming moderate lobes laterally. Both lips with small, inconspicuous, sparse tubercles, those on upper lip in three or four series. In other specimens these can not be detected, owing, perhaps, to poor state of preservation. Snout 2½ or 2⅔ in head. Interorbital width 2⅛ (2¼ in young). Vertical depth of head at mandibular articulation 2¼ in length of head. Mucous canals large, with very prominent series of pores on head, as apparently in all the fishes of Klamath Lake. Gillrakers slender, triangular, their free edges densely tufted. Fontanelle narrow.

Ventrals inserted under the middle of the dorsal. Front of dorsal slightly nearer tip of snout than base of caudal. Anal elongate, in the adult female reaching to opposite base of median caudal rays, doubtless extending farther in adult males. Pectorals not reaching two-thirds distance to ventrals, 1⅛ in head. Ventrals extending two-thirds distance to vent.

Scales with strong concentric striæ, the radiating ridges produced into narrow projecting lobes at margin. Seventy-three scales in the course of the lateral line; 13 in an oblique series downward and

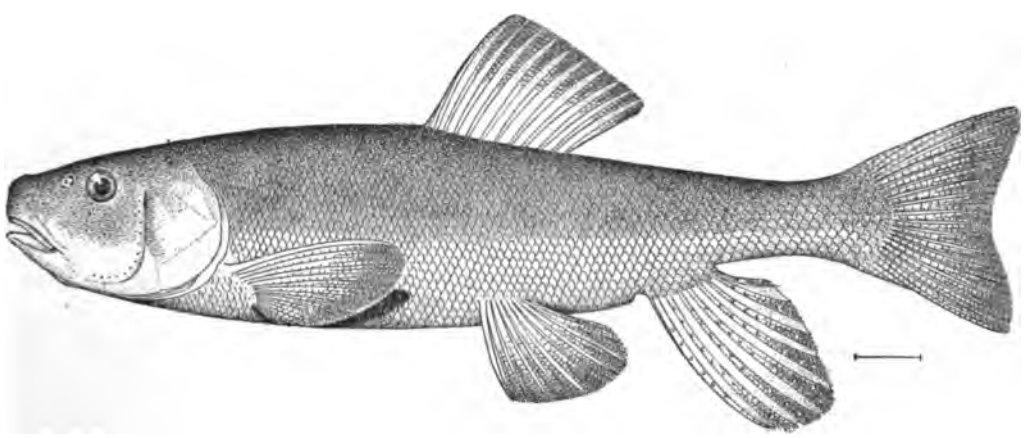
backward to lateral line from in front of dorsal; 11 in a series upward and forward from base of ventrals to lateral line; 32 or 33 oblique series crossing back in front of dorsal fin.

Color dark on upper portions of head and body, silvery on belly and lower part of sides. Fins all dusky.

The Indians to whom this fish was shown failed to distinguish it from *Catostomus snyderi*, applying to both of them the name *Yen*.

Below is a table of proportionate measurements of three specimens, the unit being hundredths of the standard length.

| Measurements. | No. 1. | No. 2. | No. 3. |
|---|---|---|---|
| Total length in mm | 370 | 250 | 195 |
| Length of head | 22 | 21⅛ | 22⅛ |
| Length of mandible | 7 | 8 | 7⅛ |
| Length of maxillary | 5 | 6 | 5⅛ |
| Depth of head at mandibular joint | 9⅛ | 10⅛ | 10⅛ |
| Interorbital width | 10 | 10⅛ | 10 |
| Depth of caudal peduncle | 8⅛ | 9⅛ | 8⅛ |
| Length of caudal peduncle | 16 | 16⅛ | 17 |
| Snout to insertion of dorsal | 48 | 50 | 48 |
| Snout to insertion of ventrals | 52 | 57 | 55 |



*Chasmistes stomias* Gilbert, new species. Drawn by A. H. Baldwin from the type (No. 48223, U. S. N. M.) from Upper Klamath Lake.

**6. Chasmistes stomias**, new species. Klamath name, *K-ahp-tu*.

Type, No. 48223, U. S. N. M. Type locality, Upper Klamath Lake, Oregon. Collectors: Gilbert, Cramer, and Otaki.

Distinguished from all species of the genus except *C. brevirostris* by the small scales. From the latter, as already indicated, it differs in the deeper head, larger mandibles, more steeply inclined mouth, and by the presence of strongly marked protuberances on the upper side of the snout, caused by the protruding spines of the premaxillary processes.

Mouth inclined at an angle of over 45°. Maxillary longer than in *C. brevirostris*, but scarcely reaching vertical from front of nostril, its length contained 1¼ times in snout. Length of mandible exceeding that of snout in adults, in one specimen equaling distance from tip of snout to middle of eye. Lips thin, the lower interrupted at symphysis, forming narrow lateral lobes. In none of our specimens can we detect papillæ on either lip. The lower lip is ridged and slightly fringed on its lower edge. Snout 2⅓ to 2¼ in head. Interorbital width 2⅛ to 2¼. Vertical depth of head at mandibular articulation 2⅛ in length of head. Mucous canals raised to form narrow ridges, the pores conspicuous. Gillrakers long, narrowly triangular, the free margins densely tufted. Fontanelle very narrow, often shortened by a coalescence of posterior halves of parietals. In adults a median frontal crest often developed.

Ventrals inserted under middle of dorsal. Front of dorsal usually nearer tip of snout than base of caudal. Anal long, the rays extending beyond base of caudal in adult males. Pectorals nearly

reaching ventrals, the latter extending to vent in adult. Dorsal with 11 or 12 fully developed rays, anal with 7, the last ray in each divided to base.

Scales more crowded and irregular in adults of this species than in *C. brevirostris*, the posterior very conspicuously larger than the anterior. This difference between the two species is less marked in the young. The ridges on the scales are less strong in *C. stomias*. 76 to 82 scales are traversed by the lateral line; 14 or 15 scales in an oblique series downward and backward from in front of dorsal to lateral line; 11 in a series vertically upward from insertion of ventrals to lateral line; 35 to 38 oblique series before dorsal.

Upper portions of head and body blackish, the lower parts whitish or silvery, the two colors separated along a definite line traversing sides midway between lateral line and insertion of ventrals. Mandible, preopercle, and the contiguous part of cheeks whitish. Fins dusky.

Abundant in Upper Klamath Lake, where all seen were spent fish in a badly mutilated and dying condition.

Following is a table of measurements, the unit being hundredths of the standard length:

| Measurements. | No. 1. | No. 2. | No. 3. |
|---|---|---|---|
| Total length in mm | 370 | 380 | 220 |
| Length of head | 27½ | 27½ | 25 |
| Length of mandible | 11 | 12 | 9½ |
| Length of maxillary | 8 | 8½ | 6½ |
| Depth of head at mandibular joint | 13 | 14 | 12 |
| Interorbital width | 12½ | 13 | 11 |
| Depth of caudal peduncle | 9½ | 9 | 8½ |
| Length of caudal peduncle | 18 | 16½ | 17 |
| Snout to insertion of dorsal | 48 | 50 | 48 |
| Snout to insertion of ventrals | 54 | 57½ | 57 |

**7. Deltistes luxatus** (Cope).

*Chasmistes luxatus* Cope, American Naturalist 1879, 784, Upper Klamath Lake and tributaries; Proc. Ac. Nat. Sci. Phila. 1883, 149.

*Catostomus rex* Rosa Smith Eigenmann, American Naturalist 1891, 667, Lost River, Oregon.

*Deltistes luxatus* Alvin Seale, Proc. Cal. Ac. Sci. 1896, 269.

The "Lost River sucker" is the most important food-fish of the Klamath Lake region. It is apparently resident during most of the year in the deeper waters of Upper Klamath and Tule lakes, running up the rivers in incredible numbers in March and April, the height of the run varying from year to year according to the condition of the streams. The Lost River fish are the most highly prized and are said to be much fatter and of finer flavor than those ascending the tributaries of Upper Klamath Lake. Prior to 1894 an attempt had been made to preserve the meat in cans, but apparently with poor success. Oil had also been extracted from heads and entrails, said to be worth from 60 to 85 cents per gallon.

The species most closely resembles in appearance *Chasmistes fecundus*, from which it differs principally in the simpler gillrakers, as already noted by Mr. Seale. It agrees with *C. fecundus* and differs from other species of *Chasmistes* in its very long, slender head, its small, nearly horizontal mouth, and thicker lips. When these species shall have been thoroughly investigated, *C. fecundus* will probably be separated generically from *Chasmistes*.

At the time of our visit to Upper Klamath Lake, June 13 to 16, the run of suckers was well over, and the only specimens observed were the dried heads on the banks of Lost River and some more or less diseased and mutilated individuals floating about in Upper Klamath Lake and River. One young specimen only could be preserved, from which the following notes are taken:

Head 4 in length; depth 4⅓. D. 12. A. 7. Lat. line 78.

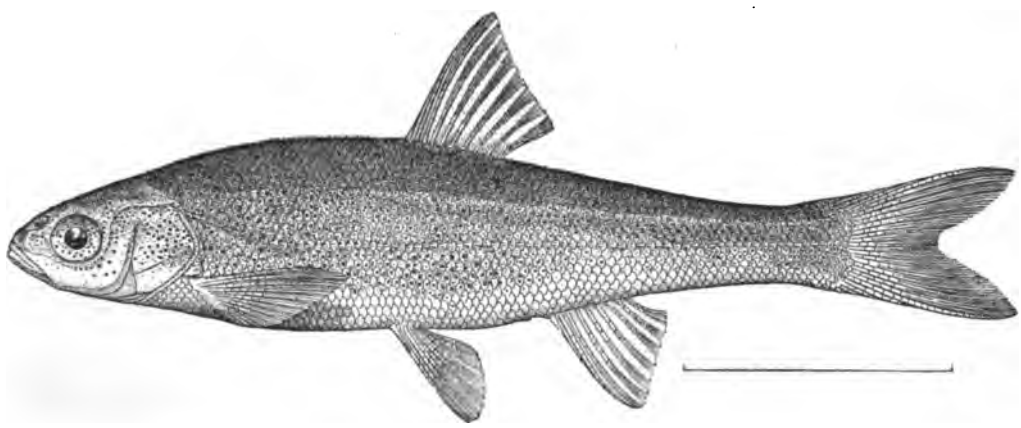
Head very long and slender, the snout and cheeks especially so, the mandibles inclined upward at an angle of about 35°. Snout tapering to a very slender tip, on the under side of which is the very small, nearly horizontal mouth, little overpassed by the premaxillaries. Premaxillary spines forming a decided hump on upper surface of snout near tip. Maxillary not reaching vertical from nostril, half length of snout. Snout 2¾ in head; interorbital width 2½; diameter of orbit (measured just within the bony rim) 5¾. Lower lip thin, but thicker and wider than in typical *Chasmistes*, the two lobes widely separated at symphysis, which is very narrowly bordered; upper lip very narrow; several series of minute papillæ on each lip. Very conspicuous mucous canals on top and sides of

head. Gillrakers short, triangular, somewhat wider than in species of *Chasmistes*, their free margins plain or moderately fringed, not bearing the dense mass of short, divided processes so conspicuously developed in *C. fecundus* and to a less degree in other species of *Chasmistes*.

Scales with concentric lines and radiating ridges very strongly marked. Seventy-eight pores in the lateral line; 14 scales in an oblique series from median line before dorsal downward and backward to lateral line; 9 scales between lateral line and base of ventrals. In 9 specimens not preserved the pores in lateral line were as follows: 76, 78, 78, 79, 79, 79, 79, 80, 81. Thirty-four series of scales before dorsal.

Ventrals inserted about under middle of dorsal. Front of dorsal slightly nearer snout than base of caudal. Last dorsal ray more than half the length of the first, which is equal to distance from snout to preopercle. Pectorals not nearly reaching ventrals, the latter not reaching vent. Anal high, the anterior rays reaching rudimentary caudal rays when deflexed. Dorsal with 12 rays, the last one divided to base. In six other specimens counted the dorsal rays were 11, 11, 11, 11, 11, 12. Anal constantly with 7 rays (in eight specimens), the last divided to base.

Very dark above, silvery on belly and lower part of sides. Dorsal and caudal dusky, the lower fins dusky on terminal half, light at base.



*Leuciscus bicolor* (Girard).—Drawn by Anna L. Brown from a specimen from Upper Klamath Lake.

**8. Leuciscus bicolor** (Girard).

*Tigoma bicolor* Girard, Proc. Ac. Nat. Sci. Phila. 1856, 206.

*Cheonda cærulea* Girard, l. c., 207. Lost River, Oregon.

*Squalius cæruleus* Cope, Proc. Ac. Nat. Sci. Phila. 1883, 146. Klamath Lake.

Abundant in Upper Klamath Lake and Lost River. A large species with compressed body, a tapering caudal peduncle, a small compressed head tapering to an acute snout. The snout is usually slender wedge-shaped, with straight outlines; in exceptional cases blunter and heavier. The mandible is usually included, but projects slightly at tip in some of our specimens. The mouth is gently oblique, the maxillary reaching vertical from front of orbit or slightly beyond it, its length 3¼ to 3½ in head. Eye 5 to 5½ in head in adults, 1⅔ to 1½ in interorbital width. Teeth 2, 4–5, 2 or 2, 5–5, 2, all of them comparatively small, with deeply grooved grinding surface, in adult specimens with the hooks obsolete. The teeth differ strikingly from those in *L. lineatus*, in which they are much larger, with strong hooks and with grinding surface convexly rounded, or in older specimens beveled by use. In *L. intermedius* they are hooked and channeled.

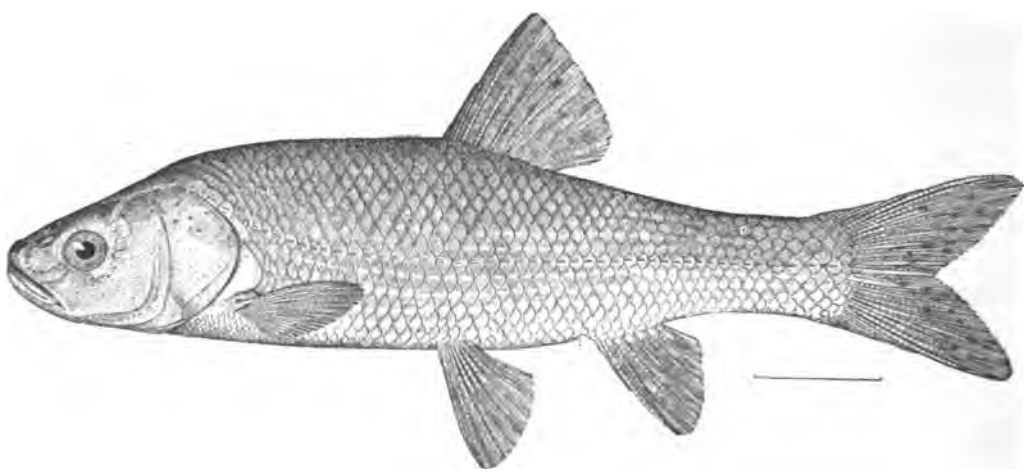
Scales marked with strong concentric lines and radiating ridges, as in *L. lineatus*. In seven specimens examined, the scales range from 65 to 67 in the course of the lateral line, 14 or 15 in an oblique series running downward and backward from the median line before dorsal to the lateral line, and 30 to 32 before dorsal (enumerating the oblique series which cross the median line).

The dorsal fin is inserted distinctly behind the ventrals and has the upper margin straight when spread, slightly concave when closed. There are usually 9 developed rays, of which the first is unbranched, the last forked to base. In 20 specimens examined, but one had 8 dorsal rays. Anal with 8 rays, the first unbranched, the last forked to base; 2 out of 20 specimens examined have 9 anal rays. The pectorals do not nearly reach the ventrals, the ventrals usually not to vent.

Color dusky above, silvery below, the middle and lower part of sides darkened by numerous coarse, black specks, which are also numerous on opercles and upper portion of cheeks. Dorsal and caudal dusky. Basal portion of anterior anal rays and inner face of pectorals dusky, the inner face of ventrals sometimes minutely black-punctate in adults. The sharp division of color between upper and lower parts, which suggested the name *bicolor*, is usually not very evident.

The following table gives proportionate measurements in hundredths of the length from tip of snout to base of caudal, in four specimens from Klamath Lake:

| Measurements. | No. 1. | No. 2. | No. 3. | No. 4. |
|---|---|---|---|---|
| Total length in millimeters | 250 | 175 | 120 | 92 |
| Length of head | 27 | 26 | 26 | 24 |
| Length of snout | 8 | 7 | 7 | 6 |
| Diameter of eye | 5 | 5 | 6 | 6 |
| Interorbital width | 9 | 8 | 8 | 8 |
| Length of maxillary | 8 | 8 | 7 | 7 |
| Greatest depth | 27 | 27 | 26 | 22 |
| Least depth of caudal peduncle | 10 | 10 | 11 | 9 |
| Length of caudal peduncle | 23 | 23 | 23 | 23 |
| Distance snout to front of dorsal | 54 | 54 | 50 | 52 |
| Snout to ventrals | 51 | 50 | 48 | 50 |
| Base of dorsal | 12 | 13 | 13 | 13 |
| Base of anal | 10 | 9 | 11 | 11 |
| Height of anal | 15 | 14 | 16 | 16 |
| Height of dorsal | 19 | 18 | 19 | 19 |
| Length of pectoral | 18 | 17 | 20 | 18 |
| Length of ventral | 15 | 15 | 16 | 15 |
| Length of caudal | 23 | 22 | 25 | ..... |



*Rutilus bicolor* (Girard).—Drawn by Anna L. Brown from a specimen from Upper Klamath Lake.

**9. Rutilus bicolor** (Girard).

*Algansea bicolor* Girard, Proc. Ac. Nat. Sci. Phila. 1856, 183. Klamath Lake.

*Myloleucus parovanus* Cope, Proc. Ac. Nat. Sci. Phila. 1893, 143. Klamath and Goose lakes.

*Myloleucus thalassinus* Cope, l. c., 144. Goose Lake.

† *Myloleucus formosus* Cope, l. c., 144. Silver, Chewaucan, and Warner lakes. Not *Algansea formosa* Girard.

† *Leucos bicolor* Jordan & Henshaw, Report Chief of Engineers, Geogr. Surv. W. 100th Mer., 193, 1878. Warner Lake.

This species is very similar in appearance to *R. obesus* from the Truckee and Humboldt rivers and their connecting lakes, differing only in the larger scales and the additional ray in the dorsal fin. The body is robust, the mouth oblique, the snout not obtuse. The maxillary reaches the vertical from front of eye in adults and is shorter in the young. Snout 3½ to 4 in head; eye 5¼ in adults; interorbital width 2⅔ to 3⅛. Head 3¼ to 3½ in length; depth 3½ to 4. Teeth 4-5, the cutting edge broad and deeply channeled in young and adults, the hook largely obsolete in the latter.

Scales marked with strong concentric lines and radiating ridges. In fifteen specimens examined, there were 47 to 52 pores in the lateral line, 10 or 11 scales in an oblique series running from median line

before dorsal obliquely downward and backward to lateral line, and 5 or 6 between base of ventrals and lateral line. One specimen has the formula 12–56–7, but is entirely exceptional. Ten specimens examined have 20 to 23 oblique series crossing median line in front of dorsal fin. The front of dorsal is slightly behind insertion of ventrals in adults, hardly noticeably so in young, always nearer base of caudal than tip of snout. Both dorsal and anal have straight margins when the fins are spread.

The following table records the fin rays in 25 specimens. The single specimen noted with 10 ventral rays had 9 rays in the ventral of the other side.

| Fins. | No. of specimens. | No. of rays. |
|---|---|---|
| Dorsal | 4 | 8 |
| | 19 | 9 |
| | 2 | 10 |
| Anal | 1 | 7 |
| | 24 | 8 |
| Ventral | 2 | 8 |
| | 22 | 9 |
| | 1 | 10 |

The pectorals fall far short of the ventrals, and the ventrals reach to or nearly to the vent.

As in other related species, the color is dark steel-gray above with greenish luster, growing lighter on lower half of sides. Belly white. Lower half of sides coarsely specked with black. Fins all dusky. No dark stripe along sides of head or body, and no orange on head or in axil of fins.

The following table gives proportionate measurements of parts in four specimens from Upper Klamath Lake, the unit of measurement being hundredths of the standard length from tip of snout to base of caudal:

| Measurements. | No. 1. | No. 2. | No. 3. | No. 4. |
|---|---|---|---|---|
| Total length in millimeters | 206 | 155 | 130 | 100 |
| Length of head | 30 | 27 | 27½ | 26 |
| Length of snout | 8½ | 8 | 7½ | 6½ |
| Diameter of eye | 5½ | 5½ | 6 | 7 |
| Interorbital width | 9½ | 10 | 9½ | 9½ |
| Length of maxillary | 8½ | 7½ | 7½ | 7½ |
| Depth of body | 26½ | 29 | 27½ | 25 |
| Depth of caudal peduncle | 12 | 12 | 11½ | 11½ |
| Length of caudal peduncle | 20 | 21 | 21 | 21 |
| Distance, snout to front of dorsal | 55½ | 53½ | 53 | 52½ |
| Distance, snout to front of ventrals | 53 | 52 | 52 | 52 |
| Length of base of dorsal | 13½ | 13½ | 13½ | 13½ |
| Length of base of anal | 9 | 9½ | 9½ | 9 |
| Height of dorsal | 19 | 17 | 19½ | 19½ |
| Height of anal | 15½ | 13 | 16 | 14 |
| Length of pectorals | 18 | 17 | 17½ | 18 |
| Length of ventrals | 17 | 16 | 15½ | 16 |

Numerous specimens were collected in Upper Klamath Lake and in Lost River, where it is the most abundant species. Others have been examined from Scott River, Siskiyou County, California (tributary to the Klamath River), collected by Mr. R. C. McGregor. It seems very improbable that this species should be identical with *R. paroranus* Cope, from the Utah Basin, a species which has not appeared in any recent collection. The representatives of this Great Basin type of *Rutilus* are so very similar that the status of *R. paroranus* can not be determined from current descriptions. Material from the other lakes in southern Oregon must also be carefully compared with the Klamath form. *R. thalassinus* from Goose Lake seems to agree in all the details assigned, but other specimens from Silver, Chewaucan, and Warner lakes, identified by Cope with *Rutilus formosus* (Girard), have smaller scales below the lateral line than we have found in any specimen of *R. bicolor*.

**10. Agosia klamathensis** Evermann & Meek.

*Agosia klamathensis* Evermann & Meek, Bull. U. S. Fish Comm. 1897. Pelican Bay, Upper Klamath Lake.

The *Agosia* of the Klamath Basin has its closest allies in *A. yarrowi* and *A. cousii* of the Upper Colorado River. These seem to have the fins strongly falcate, at least in adults, while the Klamath form has the outlines of dorsal, anal, and caudal lobes broadly rounded, even in adult breeding males. The dorsal also averages farther forward in the Klamath species, being usually located midway between base of median caudal rays and middle of snout.

The head is 3.9 to 4.2 in length. The barbels are conspicuous and constantly present. The maxillary reaches vertical from middle of nostril. The mouth is little or not at all overlapped by the snout. In adult males the paired fins are very long, the pectorals strongly overlapping the ventrals, the ventrals reaching to or beyond front of anal. In females of the same size, these fins fail to meet. In fourteen specimens examined the scales along lateral line are 70, 71, 71, 72, 72, 72, 73, 73, 74, 74, 74, 76, 77, 77. The species seems to differ from *A. nubila carringtoni* only in the smaller scales.

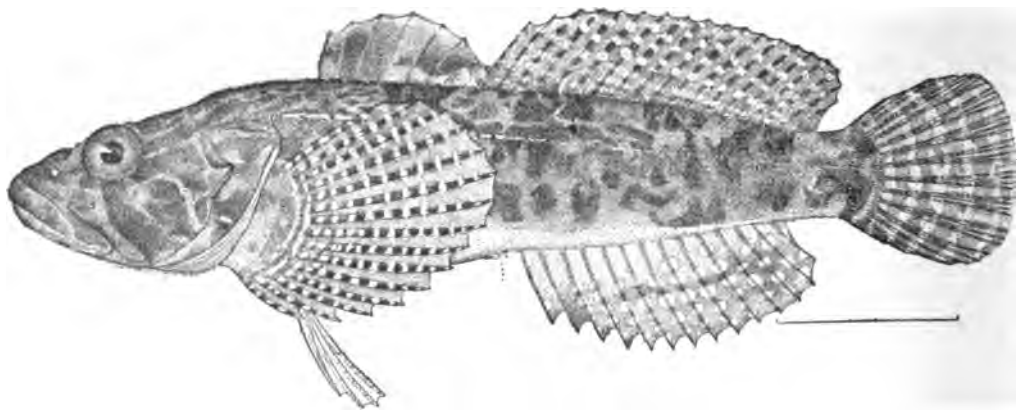
Numerous specimens were secured in Willow Creek, at Ager, California, and in Lost River. One specimen was taken in Upper Klamath Lake.

**11. Salmo gairdneri** Richardson.

Very abundant in Upper Klamath Lake and River; but few specimens obtained by us. These I am unable to distinguish from typical *S. gairdneri*, the larger specimens with the characteristic appearance of sea-run or landlocked fish, i. e., with few small spots and a truncate tail. Young specimens are also more silvery and with fewer spots than are found in *S. gairdneri* from coastwise streams. There is no patch of fine teeth at the base of the hyoid, nor any red dashes under the mandible. In five specimens examined, the scales are 134, 135, 136, 143, 146. As the California Fish Commission has operated on the Klamath River, it is not improbable that one or more species of trout have been planted there.

**12. Salvelinus malma** (Walbaum).

Reported by Cope from Williamson River; not seen by us.



*Cottus klamathensis* Gilbert, new species. Drawn by Anna L. Brown from the type (No. 48226, U. S. N. M.) from Upper Klamath Lake.

**13. Cottus klamathensis,** new species.

*Uranidea minuta* Cope, Proc. Ac. Nat. Sci. Phila. 1883, 152 (Klamath Lake); not of Pallas.

Type, No. 48226, U. S. Nat. Mus.; Upper Klamath Lake near Klamath Falls, Oregon, June 12, 1894. (C. H. Gilbert, Frank Cramer, and K. Otaki, collectors.)

A large, strongly marked species, very abundant in Upper Klamath Lake. It is characterized by its short, spinous dorsal, broadly joined to the long, soft dorsal, the unbranched pectoral rays, the very incomplete lateral line, the weak development of prickles, the lack of palatine teeth, and the distinctive coloration. It is most nearly related to *C. perplexus*.

Head $2\frac{15}{16}$ to $3\frac{1}{16}$ in length; depth $3\frac{5}{16}$ to $4\frac{1}{4}$. D. VII, 19; A. 14; P. 15; V. 1, 4.

Body heavy and deep, the head narrowed and wedge-shaped anteriorly, the snout rather acute, and the mouth with much lateral cleft. Maxillary broadly exposed, its tip reaching vertical from behind front of pupil, its length $2\frac{1}{3}$ or $2\frac{1}{4}$ in head. Broad bands of teeth on jaws and vomer; palatines toothless. Anterior nostril with a distinct tube. Eye of moderate size, $1\frac{1}{3}$ in snout, $4\frac{1}{2}$ to 5 in head. Interorbital space and occiput gently concave in adults, the total interorbital width $1\frac{1}{2}$ to $1\frac{1}{3}$ in orbit, the bony septum narrower.

Upper preopercular spine robust, straight, directed backward, or backward and slightly upward. Below this the margin of the bone is without evident spines, but bears one or two slight prominences, which may be rounded or acute. Anterior angle of subopercle with a short spine directed forward; opercle ending in a short, flat spine. Head with large pores; two pairs above front of orbit, those

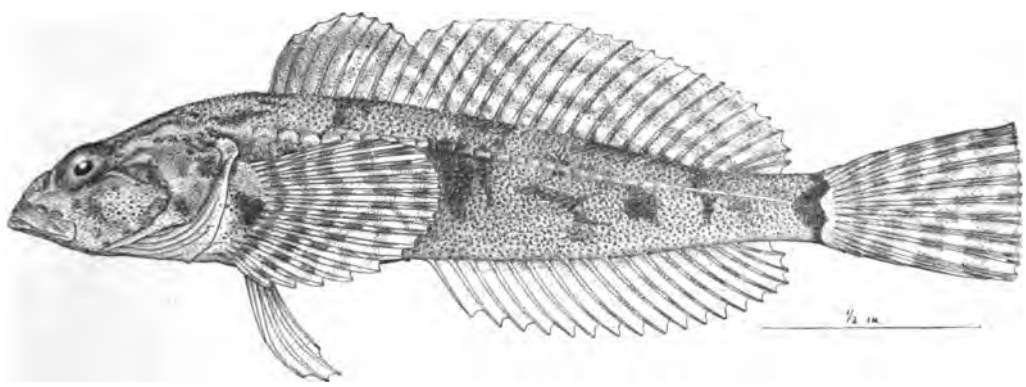
of the posterior pair nearest together; distant from these a single median pore on posterior portion of interorbital space, from which diverge two lines of pores around the back of the orbits.

The spinous dorsal is short and low, the longest spine usually less than two-thirds the longest soft ray. The two fins are very broadly joined. Distance from base of last dorsal ray to base of caudal slightly less than depth of caudal peduncle. Caudal short and broadly rounded, its length 1⅔ in head. Pectorals very short, usually not reaching vertical from front of anal, 1⅓ in head. Ventrals large, sometimes reaching vent, but usually shorter, 1¼ in head. Caudal with 9 (sometimes 8 or 10) forked rays; rays of other fins, including all pectoral rays, simple, unbranched.

| Locality. | No. of specimens. | Spinous dorsal. | | Soft dorsal. | | | Anal. | | | Pectoral. | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | VII. | VIII. | 18. | 19. | 20. | 13. | 14. | 15. | 14. | 15. |
| Klamath Lake | 21 | 19 | 2 | 1 | 18 | 2 | .... | 16 | 5 | 3 | 18 |
| Klamath River below lake | 4 | 3 | 1 | .... | 4 | .... | 1 | 3 | .... | .... | 4 |
| Lost River | 7 | 7 | ..... | 3 | 3 | .... | 2 | 4 | 1 | 3 | 5 |
| Scott River | 1 | 1 | ..... | .... | 1 | .... | .... | 1 | .... | .... | 1 |

Skin mostly naked, the young with a narrowly oblong patch of prickles below the lateral line and under the posterior half of pectorals. These become gradually absorbed with age, adults being nearly or quite naked. Lateral line very incomplete, the last pore under some portion of the anterior half of soft dorsal in all our specimens from the lake. From the last pore a shallow open groove or trace follows the course of obsolete portion of the canal. In four specimens from Klamath River below the falls, and in one collected by Mr. R. C. McGregor in Scott River, Siskiyou County, California (a tributary of Klamath River), the lateral line is much more nearly complete, ending under the last fifth of soft dorsal.

Color brownish-olive, with four or five indistinct dark bars downward from back, breaking up below into narrow bars which may unite to form V-shaped markings, or often into mere irregular blotches. A narrow bar at base of tail. Caudal with broad dark bars alternating with much narrower light ones. Dorsal and anal with somewhat narrower oblique bars. Pectorals very conspicuously checkered, the dark and light spots on the rays arranged in vertical series.



*Cottus evermanni* Gilbert, new species. Drawn by Chloe Lesley from the type (No. 48228, U. S. N. M.) from Lost River, Oregon.

**14. Cottus evermanni**, new species.

Type, No. 48228, U. S. Nat. Mus. Type locality, Lost River near Lostine, Oregon. (C. H. Gilbert, Frank Cramer, K. Otaki, collectors.)

Characterized by the long slender body entirely covered with coarse prickles, the short spinous dorsal very broadly united to the very long soft dorsal, the long anal fin, the incomplete lateral line, the very large pores on head, the branched pectoral rays, and the absence of any distinctly projecting preopercular spine.

Head 3⅓ in length; depth 5; depth of caudal peduncle 2¾ in greatest depth. D. VII, 21; A. 18; P. 16; V. I, 4.

Head small, depressed, narrowing rapidly forward, the snout more acutely rounded than in *C. punctulatus*. Mouth with distinct lateral cleft, the maxillary reaching a vertical immediately in

advance of pupil, 2⅓ in head. Mandible slightly protruding. Teeth in narrow bands on jaws, vomer and palatines, the latter very weak, apparently concealed in part beneath the skin. Total interorbital width about two-thirds diameter of eye, shallowly concave. Occipital area flat or gently convex. Eye small, 1⅛ in snout, 5 in head. Pores on head unusually large, the most conspicuous occurring on suborbital ring, along mandible and preopercle, and in a horizontal line above opercle. Three pores form a straight transverse line behind the orbits. A short nasal tube. The upper preopercular spine is represented by a short triangular process, the margin of the bone below it being smoothly rounded.

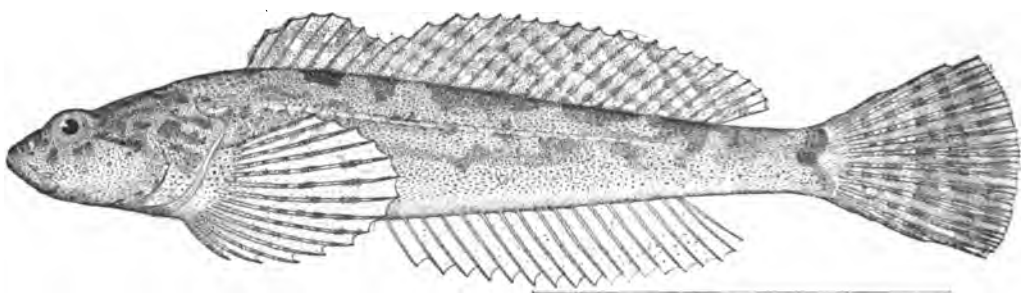
Spinous dorsal short and comparatively very high, the longest spine slightly more than three-fourths the longest soft ray. The last spine is higher than the first and about four-fifths the longest, the least height of the membrane joining last spine to first soft ray exceeding length of snout. Longest ray of soft dorsal slightly more than half head. All the rays of dorsal and anal fins simple, unbranched. Caudal long and narrow, nearly truncate when spread, six-sevenths length of head. Nine caudal rays are branched at tip for about one-fifth length of rays. The pectoral reaches the vertical from fourth ray of soft dorsal. The upper ray is simple, the next six or seven forked, the remaining rays being simple, thickened, with incised membranes. Ventrals with 1 spine and 4 rays, not reaching vent, 1⅓ in head.

Lateral line conspicuous anteriorly, running high, interrupted under eleventh or twelfth ray of soft dorsal, a mere trace visible thence to base of caudal. Sides of body thickly covered with coarse prickles, the head, breast, belly, and a narrow strip along base of anal fin naked.

Color light brownish, faintly vermiculated with darker, with traces of five irregular cross-bars from back, and a narrow distinct bar at base of caudal. Pectorals, dorsal, and caudal cross-barred.

One specimen, 59 mm. long, from Lost River, near Klamath Falls, Oregon.

Named for Dr. Barton W. Evermann, the energetic investigator of American fresh-water fishes.



*Cottus princeps* Gilbert, new species. Drawn by Anna L. Brown from the type (No. 48227, U. S. N. M.) from Upper Klamath Lake.

**15. Cottus princeps, new species.**

Type, No. 48227, U. S. Nat. Mus. Type locality, Upper Klamath Lake, Oregon. (Gilbert, Cramer, and Otaki, collectors.)

Head 3⅓ to 3⅗ in length; depth 5 to 5⅘. D. VI or VII, 21 to 23. A. 16 to 18. V. I, 4. P. 15.

A slender form with small narrow head, which is nearly quadrate in cross-section, the opercles and cheeks being subvertical, the greatest width of head but one-fifth or one-sixth more than its depth at occiput. Mouth small, oblique, the gape slightly curved, the maxillary reaching a vertical crossing eye in front of pupil, 2⅔ to 3 in head. Eye equaling snout, 4⅓ in head.

Teeth small, uniform, in narrow bands in the jaws. Vomer with a narrow patch; palatine smooth. Eye small, separated by a narrow, flat interspace, as wide as pupil. Margin of preopercle evenly rounded, without developed spine, a minute spinous point sometimes occupying the position of the upper preopercular spine. Opercle without spine. Tubes and pores of head extraordinarily developed. A series of six very large pores across cheeks and on lower edge of preorbital. A large median pore at symphysis, and a series of seven occupying each ramus and extending onto edge of preopercle. Similar, somewhat smaller, pores form the supraorbital series. Branchiostegals 6. Gill membranes broadly united to the isthmus, without free fold. No pore behind last gill.

Dorsal and anal fins very long and low, the dorsal spines very slender, the notch shallow between spinous and soft portions. Pectorals reaching beyond front of anal; ventrals usually to vent.

About two-thirds of our specimens have the back and sides completely invested with minute close-set prickles, the head and belly and a narrow area along base of anal naked. The caudal peduncle is also naked in varying degree. In the remaining third (possibly males) the body is

smooth except for a postaxial band of prickles, and in one specimen these are absent, leaving the body entirely naked. Lateral line variously incomplete, interrupted at some point under posterior half of second dorsal.

Color light olive with darker markings, which may on the head take the form of vermiculating lines. Seven quadrate dark blotches along base of dorsal fin, the first and third usually narrower than the others, an eighth on back of caudal peduncle. Very distinctly marked individuals show a series of blotches along middle of sides, which may be connected with the dorsal series by broad, dusky bars. Dorsal, caudal, and pectoral with faint bars. Ventrals and anal unmarked.

I subjoin table of fin rays in 12 specimens.

| Fins. | No. of specimens. | Spines or rays. |
|---|---|---|
| Dorsal spines | 3 | VI |
| | 9 | VII |
| Dorsal rays | 7 | 21 |
| | 4 | 22 |
| | 1 | 23 |
| Anal rays | 2 | 16 |
| | 7 | 17 |
| | 3 | 18 |
| Pectoral rays | 1 | 14 |
| | 11 | 15 |

Numerous specimens were obtained in shallow water along the shore of Klamath Lake, on a bottom of fine sediment and vegetable débris.

This differs widely from any other species of *Cottus* in the very narrow, slender form, the long fins, and especially in the extreme development of the mucous tubes and pores.

# 2.—A REPORT UPON SALMON INVESTIGATIONS IN THE COLUMBIA RIVER BASIN AND ELSEWHERE ON THE PACIFIC COAST IN 1896.

By BARTON WARREN EVERMANN and SETH EUGENE MEEK.

During the season of 1896 the United States Fish Commission conducted a number of investigations in Idaho, Washington, and Oregon, having for their general purpose the improvement and extension of the fish-cultural operations of the Commission on the Pacific Coast. The specific object of each inquiry, the details of the work, and results accomplished are given in the following pages. The work was under the immediate direction of Professor Evermann, assisted by Dr. S. E. Meek, associate professor of biology and geology in Arkansas State University; Mr. Ulysses O. Cox, professor of biology in the State Normal School at Mankato, Minn.; Mr. A. B. Alexander, fishery expert of the Fish Commission steamer *Albatross;* Mr. W. F. Hubbard, superintendent of the United States fish-hatchery at Clackamas, Oregon, and Mr. Alfred G. Maddren.

Investigations were carried on in ten different regions, as follows: (1) At the Redfish lakes in Idaho, by Messrs. Evermann, Meek, and Maddren; (2) at Lake Pend d'Oreille, Idaho, by Messrs. Alexander and Cox; (3) at Wallowa Lake, Oregon, by Messrs. Meek and Maddren; (4) on tributaries of the Lower Columbia, by Messrs. Evermann, Meek, and Hubbard, and by Messrs. Alexander and Cox; (5) on streams tributary to Puget Sound, by Messrs. Alexander and Cox; (6) at Lakes Washington, Sammamish, and Union, by Mr. Alexander; (7) on the Siuslaw River, Oregon, by Dr. Meek; (8) on Whoahink, Tsiltcoos, and Tahkenitch lakes, Oregon, by Dr. Meek; (9) at Upper Klamath Lake, by Messrs. Meek and Alexander; and (10) at Crater Lake, Oregon, by Messrs. Evermann and Cox.

During the progress of this work the representatives of the Commission were the recipients of material assistance and many acts of courtesy from various citizens, to all of whom we are glad to acknowledge our indebtedness and to express our thanks. Especial mention should be made of Mr. G. H. Stevenson, Vancouver, Wash.; Seufert Brothers and Mr. I. H. Taffe, salmon canners at Celilo, Oregon; Mr. Frank Warren, salmon-canner at Portland; Captain Steers, of the steamer *Lillian*, Florence, Oregon; Mr. William Kyle and Messrs. Elmore & Sanborn, salmon-canners at Florence; Mr. Leonard Christianson, of Acme, Oregon, and Mr. Scott Morris, of Ada, Oregon.

## THE REDFISH LAKES, IDAHO.

It was found in 1894 that these lakes and their connecting streams afforded unusually good facilities for the study of the spawning habits of the chinook salmon and both forms of the so-called redfish. The matter was taken up in the following year and a continuous series of observations was carried on at those lakes from July 17 to September 24. A detailed account of those observations, together with full descriptions of the physical features of the region, may be found in the published report, in the Bulletin of the United States Fish Commission for 1896, pp. 149–202.

The investigations of 1895 resulted in the following conclusions concerning a number of important questions regarding these fishes, viz:

1. The chinook salmon resorting to the headwaters of Salmon River for spawning purposes reach the spawning-grounds in perfect condition, so far as shown by external appearances, no mutilations nor injuries of any kind having been seen. The many sores and mutilations seen upon them later in the season result from injuries incident to spawning, are received on the spawning-beds, and are not due to injuries received en route from the sea.

2. After spawning, the chinook salmon coming to these waters die in the vicinity of the spawning-beds.

3. The young chinook salmon remain about one year in the streams where they were hatched before beginning their journey to the sea.

4. The large redfish are identical with the blueback salmon, or sockeye (*Oncorhynchus nerka*), and come up from the sea, as do the chinook salmon. They reach the spawning-beds in perfect condition, are mutilated there during the spawning season, and then die, never returning to the sea.

5. The small redfish spawn at the same time and on the same beds with the large redfish. They arrive upon the spawning-beds in apparently perfect condition, but soon become mutilated, just as do the large form and the chinook salmon, and then die without returning even to the lake.

6. Eggs of the small redfish laid in September in the inlet to Alturas Lake began hatching on the 21st of March following.

7. The young redfish remain in Alturas Lake at least one year from the time when they were spawned.

The investigations of 1895 left unanswered, however, some of the most important and interesting questions concerning the redfish. It was not possible to determine when the large redfish arrives at the Idaho lakes, nor whether the small form is really anadromous. Both forms were already in Alturas Lake before the nets were set in the outlet, on July 20. The importance of settling these questions, if possible, and the desirability of repeating and verifying the observations of 1895, justified the continuance of the work another season. Alturas Lake was, therefore, again visited in the summer of 1896. Camp was established July 11 on the outlet of Alturas Lake, at the ford about 1½ miles below Perkins Lake. On account of unusually high water it was impossible to set the gill nets satisfactorily until July 17. On July 22 the camp was moved to the head of Alturas Lake and a gill net was placed across the inlet at its mouth. The net at the ford was taken up August 6 and reset in the outlet between Perkins and Alturas lakes, thus making it more easily reached from the camp. It remained in this place until September 25, when it was taken up and not reset again. Redfish began to come into the inlet August 3. After that date the net was kept in place only at irregular intervals until August 14, when it was taken up.

*High water.*—The spring of 1896 was an unusually late one in Idaho. The snows of the preceding winter were much deeper than usual and were slow in disappearing in the spring. Rains were also uncommonly frequent, even late in the spring and during the first half of summer, the last of importance occurring August 6. A very hard rain fell on the night of August 3, resulting in a perceptible rise in the streams. On July 11 the streams were much higher than at the same time the year before. Salmon River and Alturas Creek were overflowing their banks in many places; much of the

valley above Alturas Lake was from a few inches to 3 feet under water. Not until about July 22 was it possible to reach the head of the lake with a wagon, and the outlet could not safely be forded earlier than that date. After July 14, however, the water ran down very rapidly, and during August and September Alturas Creek was only slightly higher than in 1895.

*Temperatures.*—Temperature observations were made as regularly as circumstances permitted. The records for July 11 to July 21, inclusive, are those made at the camp on the outlet of Alturas Lake. The thermometer for air temperatures was kept hanging in the shade on a tree at the camp; the water temperatures were taken in the creek at the camp in water about a foot deep.

*Temperatures recorded at the outlet of Alturas Lake, Idaho, July 11 to 21, 1896.*

| Date. | Hour. | Air. | Water. | Date. | Hour. | Air. | Water. |
|---|---|---|---|---|---|---|---|
| | | ° F. | ° F. | | | ° F. | ° F. |
| July 11 | 8 p. m. | 62 | 58 | July 17 | 8 a. m. | 55 | 55 |
| 12 | 8 a. m. | 59 | 56 | | 12 m | 73 | 60 |
| | 12 m | 71 | 58 | | 8 p. m. | 64 | 59 |
| | 8 p. m. | 52 | 55 | 18 | 8 a. m. | 55 | 58 |
| 13 | 8 a. m. | 52 | 53 | | 12 m | 74 | 63 |
| | 12 m | 60 | 55 | | 8 p. m. | 64 | 60 |
| | 8 p. m. | 55 | 53 | 19 | 8 a. m. | 52 | 58 |
| 14 | 8 a. m. | 58 | 53 | | 12 m | 72 | 62 |
| | 12 m | 70 | 58 | | 8 p. m. | 59 | 61 |
| | 8 p. m. | 62 | 54 | 20 | 8 a. m. | 56 | 58 |
| 15 | 8 a. m. | 63 | 54 | | 12.30 p. m | 73 | 63 |
| | 12 m | 71 | 57 | | 8.15 p. m | 60 | 61 |
| | 8 p. m. | 61 | 56 | 21 | 8.20 a. m | 50 | 58 |
| 16 | 8 a. m. | 60 | 60 | | 12 m | 76 | 63 |
| | 12 m | 74 | 59 | | 8 p. m. | 63 | 61 |
| | 8 p. m. | 64 | 56 | | | | |

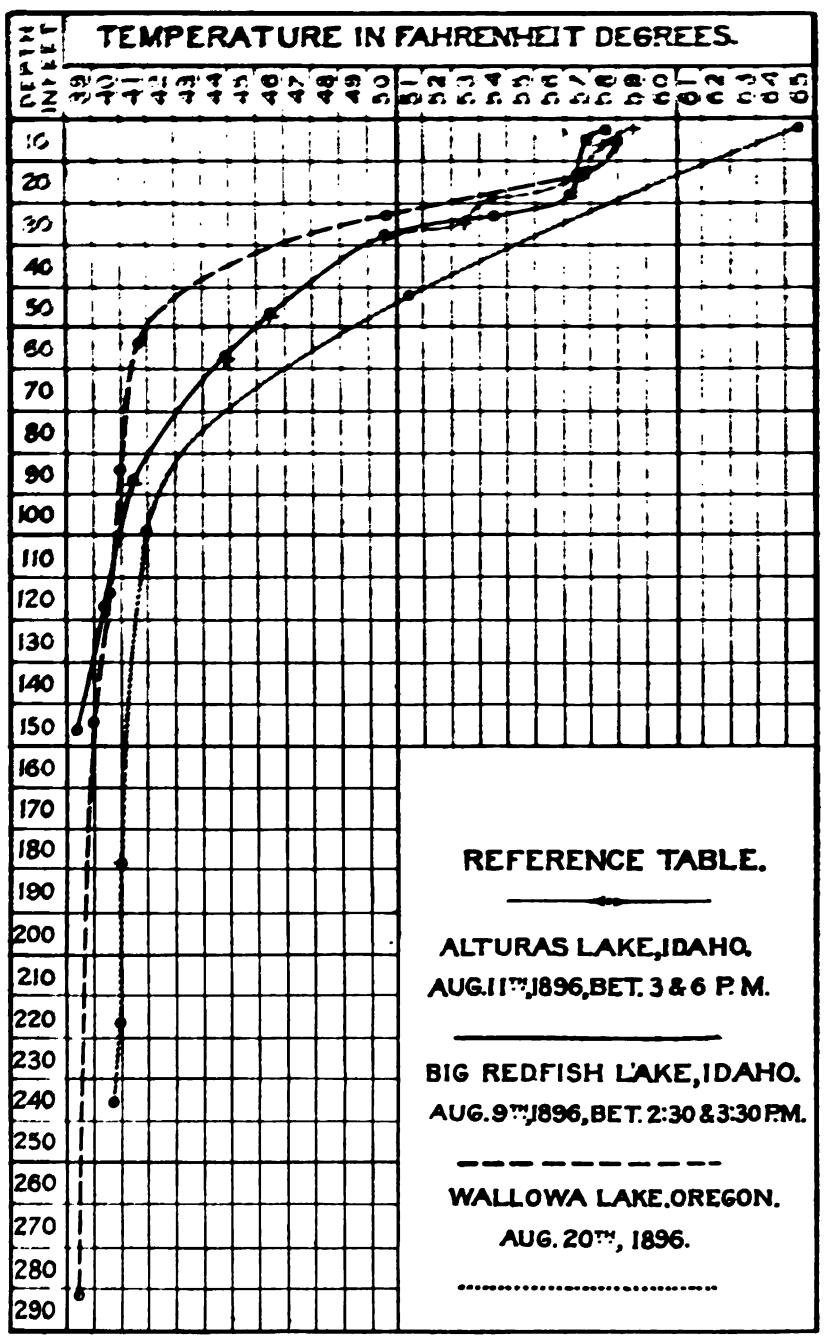
The temperatures recorded in the following table are those taken at the camp at the head of Alturas Lake. The "inlet" temperatures were taken a few feet above the lake where the water was about 2 feet deep; those for the lake were taken just in front of our camp at a depth of about 3 feet, and those of the air were in the shade:

*Temperatures recorded at the head of Alturas Lake, Idaho, July 22 to August 5, 1896.*

| Date. | Hour. | Air. | Water. | | Date. | Hour. | Air. | Water. | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Inlet. | Lake. | | | | Inlet. | Lake. |
| | | ° F. | ° F. | ° F. | | | ° F. | ° F. | ° F. |
| July 22 | 8 a. m. | 62 | ..... | 55 | July 29 | 1 p. m. | 65 | 48 | 59 |
| | 12 m | 72 | ..... | 57 | | 8 p. m. | 54 | 50 | 56 |
| | 8 p. m. | 60 | 51.5 | 50 | 30 | 8 a. m. | 49 | 43 | 56 |
| 23 | 8 a. m. | 56 | 43 | 53.5 | | 12 m | 68 | 49 | 60 |
| | 12 m | 64 | 47 | 54.5 | | 8 p. m. | 55 | 52 | 58 |
| | 9 p. m. | 48 | 49 | 51 | 31 | 8 a. m. | 53 | 44 | 56 |
| 24 | 8 a. m. | 46 | 41 | 53 | | 12 m | 74 | 50 | 59 |
| | 12 m | 64 | 47 | 55 | | 8 p. m. | 59 | 51 | 55 |
| | 8 p. m. | 56 | 51 | 51 | Aug. 1 | 8 a. m. | 59 | 44 | 58 |
| 25 | 8 a. m. | 52 | 42 | 54 | | 1 p. m. | 74 | 52 | 54 |
| | 12 m | 69 | 48 | 50 | | 8 p. m. | 59 | 53 | 55 |
| | 8 p. m. | 53 | 51 | 51 | 2 | 8 a. m. | 57 | 44 | 57 |
| 26 | 8 a. m. | 46 | 42 | 50 | | 1 p. m. | 66 | 51 | 58 |
| | 12 m | 63 | 47 | 59 | | 8 p. m. | 53 | 53.5 | 53 |
| | 8 p. m. | 53 | 51 | 56 | 3 | 8 a. m. | 49 | 44 | 57 |
| 27 | 8 a. m. | 50 | 43 | 54 | | 12 m | 70 | 49 | 57 |
| | 12 m | 64 | 47 | 58 | | 8 p. m. | 42 | 52 | 50 |
| | 8 p. m. | 60 | 50 | 59 | 4 | 8 a. m *a* | 41.5 | 42.5 | 55 |
| 28 | 8 a. m. | 48 | 55 | 54 | | 12 m | 57 | 50 | 51.5 |
| | 12 m | 57 | 51 | 56 | | 8 p. m. | 44 | 51 | 55 |
| | 8 p. m. | 49 | 49 | 56 | 5 | 8 a. m. | 42 | 42 | 55 |
| 29 | 8 a. m. | 52 | 43 | 56 | | 12 m | 60 | 44 | 56 |

*a* During the night of August 3 there were heavy thunder and rain, snow falling on the mountains.

In the following diagram are shown the temperature curves obtained by taking series temperatures in Alturas, Big Redfish and Wallowa lakes. Two series were taken in Alturas Lake and one in each of the others.



The following temperatures were taken August 11, in Alturas Lake just beyond the bar at the mouth of the inlet. All are bottom temperatures except the first three. The first, second, third, and fourth were all taken at the same place, the others a short distance away:

| | | | |
|---|---|---|---|
| 1. At surface | 57° | 5. At depth of 72 feet | 43° |
| 2. At depth of 24 feet | 54 | 6. At depth of 96 feet | 40½ |
| 3. At depth of 48 feet | 45 | 7. At depth of 102 feet | 40½ |
| 4. At depth of 90 feet | 40½ | | |

Two series of temperatures at different depths were taken in Alturas Lake August 11, between 3 p. m. and 6 p. m. These are shown on the temperature diagram on preceding page. The series indicated by the crosses shows the bottom temperatures, obtained by starting near shore in 1 fathom and going outward into increasing depths. The circles on the continuous line indicate a vertical series taken near the middle of the lake, where the depth was 150 feet. It will be noticed that, after reaching a depth of 30 feet, the two series coincide exactly and that the temperature at the bottom in the deepest part of this lake is but slightly, if at all, above that of fresh water at its greatest density, namely, 39°.

A similar series was taken at Big Redfish Lake August 9, between 2.30 and 3.30 p. m., the results of which are platted on the same diagram, an examination of which shows that this lake is, as a whole, considerably colder than Alturas Lake. Though the surface temperatures are nearly the same, the water in Big Redfish Lake is seen to grow colder much more rapidly as the depth increases. This is apparently due to the greater size and depth of Big Redfish Lake, the lower temperature of the inflowing water, and the greater protection afforded by the higher surrounding mountains. In both lakes, however, the temperature decreases rapidly until a depth of about 100 feet is reached, and beyond that depth the decrease is less than 2° in either case.

These temperatures were taken with a Negretti-Zambra deep-sea thermometer tripped by means of a messenger, and the results are believed to be reliable. The bottom temperatures which we took at these lakes in 1895 were taken with a Wilder protected thermometer, and we are now convinced that the results obtained are wholly unreliable whenever the depth exceeded a few feet. The thermometer can not be drawn up quickly enough to prevent the mercury from being warmed by the warmer water above. The few bottom temperatures given in the report of the work done on these Idaho lakes in 1895 are therefore worthless.

### SUMMARY OF OBSERVATIONS REGARDING THE REDFISH.

Camp was established on the outlet of Alturas Lake July 11, and observations began on that date. The daily inspection of the nets and the periodical examination of Alturas Creek and Salmon River were carried on essentially as during the season of 1895. Although gill nets could not be well placed until July 17, the opportunities for examining the stream make it certain that if any redfish had ascended to the lake between July 11 and 17 they would have been seen.

Beginning with July 17, gill nets were kept constantly in the outlet of Alturas Lake, set in such manner as wholly to obstruct the stream to the ascent of fish. These nets were kept in place until September 25, but not a single redfish, either of the large or small form, was caught in them. No redfish were seen in the outlet or elsewhere below Alturas Lake during the season. Small redfish appeared in the inlet in considerable numbers in August and September, but no large redfish were seen this year at any of the Redfish Lakes.

The first redfish seen was caught in Alturas Lake near the inlet July 16, while fishing for Dolly Varden trout in about 30 feet of water. It was a male, 11½ inches long, and was taken on a hook baited with salmon spawn. Its stomach was well filled with food, chiefly small crustaceans. Its color was a rich metallic blue on the back, becoming silvery on the lower sides and under parts. The reproductive organs were not greatly developed.

The next redfish were caught in the inlet gill net on the night of the 2d of August, 3 males in prime condition. On the next night 3 more males were taken, in excellent condition and nearly or quite ripe. On the next night 8 males and 3 females were caught, all the males ripe and the females nearly so. No others were seen until August 6, when about 40 were observed in a deep hole about a mile above the lake.

As the redfish were now running up in considerable numbers, the nets were taken up and not put down again except for one night, August 13, when 53 males and 32 females were caught. None of these showed any sores or mutilations of any kind.

By the middle of August the fish had arrived in large numbers, the maximum being reached during the last week in that month. The fish in the inlet were counted at intervals and a careful record made of their numbers. The record reads as follows: 1,044 fish on August 18; 1,345 on August 21; 1,038 on August 25; 1,558 on August 28; 1,354 on September 1; 1,515 on September 4; 1,286 on September 9; 1,067 on September 12; 952 on September 14; 703 on September 18; 214 on September 25; 106 on September 28; October 2, none.

The fish seen on the first few days were all in perfect condition, but soon after they began spawning mutilations appeared, and some died as early as August 23. After that date they died rapidly, but the numbers were reinforced from time to time by new schools which continued to come up from the lake until probably the first week in September. The large decrease shown August 25, compared with the number observed four days earlier, was apparently caused by a great many fish being caught out by campers. Beginning early in September the number of dead fish increased and the number of live ones gradually decreased until October 2, when all had died. The dead fish were usually found in the deeper pools or quiet portions of the inlet. On September 14 one dead redfish was found lodged against the net in the outlet a few rods below Alturas Lake, and on September 25 four were found washed up on the shore of the lake a few rods west of the inlet. These had all doubtless been carried down by the current.

*Run later than in 1895.*—In 1895 the first redfish appeared in Alturas Inlet July 25, the maximum was reached about September 6, and all had died by September 25. In 1896 the run began nine days later, the maximum was attained about nine days earlier, and the last live fish were seen about nine days later than in 1895. Though the season began a little later, it covered almost exactly the same length of time.

*Mutilations.*—Previous observations concerning the cause of the mutilations were verified. As the fish came into the inlet they were all in perfect condition, and continued and careful observation of their movements during the spawning season showed conclusively that the injuries are caused by contact with the gravel and by fighting on the spawning-beds.

*Dying of the redfish.*—The conclusion reached last year, that every redfish dies after spawning once, was based upon absolute proof, so far as this region is concerned, and no other conclusion was possible from the observations made this year. The

number of redfish entering Alturas Inlet in 1895 was about 2,000 in round numbers, and not one ever returned alive to the lake below. The run this year was somewhat larger. The greatest number counted at any one time was 1,558, but many had died or been caught by campers prior to that time, and many new schools came in subsequently. It is a conservative estimate to say that between 2,500 and 3,000 fish entered Alturas Inlet in 1896. While the observations for the purpose of determining whether any returned to the lake were not as carefully made as in 1895, there is no evidence that a single fish ever returned to the lake alive.

While the mutilations are usually quite severe, in many cases they are not particularly so, and unmutilated fish were sometimes found dead or dying. This fact seems to be of great importance because of the light which it throws upon the probable cause of the death of spawning salmon. Some naturalists have maintained that the dying is attributable to the injuries; others that exhaustion resulting from the long journey from the sea or long abstinence from the use of food is the cause; but as a matter of fact, many observers have seen salmon dying in large numbers at the end of the spawning season in waters only a few miles from the sea, and even in salt water, and the cause could, therefore, not have been exhaustion resulting from long journeys without food, or mutilations received on such journeys. That the dying results from long abstinence from food is completely disproved by observations at Alturas Lake, where redfish have been observed to come up out of the lake with food in their stomachs, and have died a few days after spawning. The true cause is evidently deeper seated in its nature and more general in its application than has been supposed.

*No large redfish seen in 1896.*—In 1894, 14 large redfish were seen in Alturas Inlet and 1 in the inlet to Pettit Lake, and as these waters were visited only once this does not, of course, indicate the total number that may have spawned there in that year. In 1895 only about 8 large redfish were seen, 3 in the inlet to Pettit Lake, 3 in Alturas Inlet, and 2 in Alturas Lake. During the season of 1896 no large redfish appeared in Alturas Inlet, nor were any seen at Pettit Lake, which, however, was not visited sufficiently often to fully determine the matter. None was observed at Big Redfish Lake during a trip there August 8 to 10, and parties who visited the lake during August and September report seeing no redfish.

*Are the small redfish anadromous?*—This question can not yet be positively answered. If they are, they had reached Alturas Lake prior to July 11, just as they must have reached it before July 20, in 1895. But this may very well be so, for the big redfish, which is undoubtedly anadromous, had also reached this lake earlier in 1895 than July 20. Observations at Alturas and Wallowa lakes point strongly to the probability of the small redfish being permanently resident in those lakes. The first of these was the catching of a small redfish in Alturas Lake July 16. This fish took the baited hook, and its stomach was found to contain some food, chiefly insect larvæ and small crustaceans. One caught in the gill net August 6 had a trace of food in its stomach. Twelve small redfish were caught with grabhooks in Wallowa Lake by Mr. J. J. Stanley, about the first of September, and the stomachs of 9 of them were found to contain food consisting almost wholly of entomostracans and other small crustaceans. In one case the stomach contained a small quantity of some alga and in five or six cases the stomach was quite full of food.

The twelve specimens taken by Mr. Stanley were males which probably would have spawned that season. They are considerably smaller than any heretofore taken and vary from 6⅜ to 9⅜ inches in total length; one found dead on the shore of Wallowa Lake August 24 is only 5¼ inches long.

In the light of all these facts it is hard to believe that the small redfish come up from the sea. On the other hand, when we consider that the large and small forms present no structural differences of value, that they spawn at the same time and on the same beds, that the small form has never been seen, so far as known, in any of these lakes except at spawning time, and that they, like other members of the genus, die after once spawning, it is equally difficult to believe that they are permanently resident in fresh water.

*Chinook salmon in the upper Salmon River.*—The number of chinook salmon coming to these spawning-beds in 1895 was not far from 1,000. The first appeared July 24, and the maximum number was reached about August 24. All arrived in perfect condition, and all died soon after spawning, none returning to the sea.

Not much time was given to the chinook salmon in 1896, only occasional visits being made to Salmon River. From such observations as were made and from information obtained from various parties who came up the river from Stanley Basin and other points below, it appears that the run was very small and much later than in the preceding year. Four were seen in Alturas Creek, at the mouth of Pettit outlet, August 24, and seven days later 7 more were seen in the Salmon River a mile below the mouth of Alturas Creek. On September 3, 8 were seen from this point down to Roaring Creek. The same fish, or possibly others, were seen at various times until September 11, after which no more were seen. Mr. Springer, who was fishing and hunting for the Custer market, says that in Bear Valley and Sulphur creeks, where salmon have until this year been plentiful, not one was seen. He saw only 1 salmon in Salmon River below Roaring Creek.

## LAKE PEND D'OREILLE, IDAHO.

In February, 1889, the United States Fish Commission placed in Lake Pend d'Oreille 1,300,000 fry of the common whitefish (*Coregonus clupeiformis*). Until now no investigation had ever been made to determine whether any of these fish survived. Fugitive reports have come to the Commission from time to time of the capture of examples of this species, but specimens submitted for identification proved to be the common native species (*Coregonus williamsoni*). If the planted species succeeded in establishing itself, the individuals would by this time have attained a size sufficient to enable them to be taken in gill nets.

Mr. A. B. Alexander and Prof. U. O. Cox were instructed to go to Lake Pend d'Oreille and endeavor to determine the result of the whitefish plant made in this lake in 1889, and to make investigations regarding the suitability of the lake, in its physical and biologic features, to the common whitefish. The investigations were begun June 25 and it was hoped they might continue through the season, but, owing to urgent work on Puget Sound, which Messrs. Alexander and Cox were directed to perform, the Pend d'Oreille investigations were discontinued July 16. Excessively high water prevailed during the time spent upon the lake and the conditions were not favorable for investigations of this kind. Gill nets were set in different places in the north end of the lake, but no tests were made in the southern portion. While no

whitefish were found, the result can not be regarded as conclusive. The investigations should be resumed and continued until the whole lake can be carefully examined.

The report upon the physical examination of the lake and upon the fish-food collected will be reserved until a more thorough study of this important body of water can be made.

## WALLOWA LAKE, OREGON.

It has been known for several years that both the large and small redfish have spawning-beds in the inlets of this lake, and that chinook salmon spawn in Wallowa River and other streams in that region. A short visit was made to Wallowa Lake by Messrs. Meek and Maddren on August 19, and they remained there and on Wallowa River until August 26.

Wallowa Lake is in the northeastern portion of Oregon and in the southern part of Wallowa County. It lies in the southern end of a considerable valley, which is bounded on the east, south, and west by the Powder River Mountains. This lake is of glacial origin, and is bordered on the east and west sides by immense lateral moraines, which rise about 1,200 feet above the surface of the lake at the upper end, but become less high as the lower end of the lake is approached. Across the broad canyon at the foot of the lake is a terminal moraine a few feet high, through which the outlet has cut its way. At the foot of each of the lateral moraines, about 20 feet above the surface of the water, is a bench from 20 to over 100 feet in width. This bench was evidently formed when the surface of the lake was at that height. The outlet has cut a sort of canyon through the terminal moraine and lowered the lake to its present level. The sides of the moraines above and below these benches are very steep, and except along the upper one-third of the lake there is very little timber on them. There is a dense growth of willows and alder along the south shore of the lake, extending backward into the valley about one-fourth of a mile. The rest of the valley near the head of the lake is quite heavily timbered.

The mountains near the head of the lake are very rugged, and are said to be over 5,000 feet above the surface of the lake.

Wallowa Lake is about 4½ miles long from north to south, with a maximum width of about 1 mile. The greatest depth found was 250 feet. Its shores are quite regular, there being no marked indentations anywhere. The beach at the upper end of the lake is sandy; that on the other three shores is for the most part covered by bowlders. The inlet of this lake has its origin in some lakes about 3 miles farther up the narrow valley. The largest of these is said to be about half a mile in diameter. About 2½ miles above Wallowa Lake are Wallowa Falls. Just before reaching this point the inlet flows through a canyon about 90 feet in depth, the height of the falls being about 50 feet. The water falls into a basin about 50 feet in diameter, the outlet of which is 15 to 20 feet wide. A great many bull trout are caught with hook and line in this basin each year. Between the falls and the lake the inlet flows most of the distance, with a swift current, over a bed of bowlders. Within about half a mile of the lake the inlet breaks up into two or more channels, and finally discharges its waters into the lake by two mouths, which are only a few rods apart. The mouth of the inlet has been changed within the past few years. The stream is very swift and contains very few gravel beds, and these are along its lower mile. Another small

inlet empties into the lake near its southeast corner; this inlet is only a small brook in summer. The lakes and the inlet above the falls are said to contain no fish life.

Wallowa River, as it leaves the lake, is a very rapid stream and flows over a bed of bowlders. The first half mile of its course is through a canyon about 30 feet deep. From Joseph to Lostine the river is said to be very rapid.

The West Fork of Wallowa River rises in the mountains west of Wallowa Lake, and, after flowing in a general northerly direction until within about a mile of the main fork at Lostine, it bends to the westward and joins the main fork a short distance below that town. About 12 or 15 miles below where these two forks come together Wallowa River is joined by Minam River, which forms a part of the western boundary of Wallowa County. The river here flows nearly due north, and soon unites with the Grande Ronde River, a tributary of Snake River.

About 4 miles from Lostine up the West Fork of Wallowa River, the river was narrower and flowed with considerable velocity among the huge bowlders scattered over its bed. About 3 miles above Lostine there is a somewhat level stretch in the river of about half a mile, which includes some gravel bars. From Lostine to the mouth of Minam River the Wallowa is a rapid stream, flowing most of the distance over a bed of bowlders. Gravel or sand bars are not common. The water is very clear, and at the time of our visit was not over 3 feet deep in this portion of the stream. Minam River is smaller and is said to be very similar to the Wallowa. The Grande Ronde River was seen at Lagrande and Elgin and at various places between those towns. It appears to be a rather sluggish stream, the water being warm and muddy.

*Soundings and Temperatures.*—The following soundings and temperatures were taken on Wallowa Lake about half a mile north of the south end of the lake. We began on the west side and counted the strokes of the oars as we crossed, taking soundings and temperature at intervals, as shown below. The first sounding was made 20 oar strokes from the west shore.

*Soundings and temperatures taken in Wallowa Lake, August 20, 1896.*

| Strokes taken between soundings. | Depth. | Temperature at bottom. | Strokes taken between soundings. | Depth. | Temperature at bottom. |
|---|---|---|---|---|---|
| *No.* | *Feet.* | °F. | *No.* | *Feet.* | °F. |
| 20 | 42 | 51 | 50 | 219 | 40⅛ |
| 100 | 216 | 40½ | 30 | 180 | 40⅝ |
| 100 | 236 | 40⅜ | 30 | 99 | 41⅛ |
| 100 | 234 | 40⅛ | 35 strokes to east shore. | | |
| 100 | 228 | 40½ | | | |

Temperature of water at surface 65°.

The greatest depth, 250 feet, was about a mile from the south end of the lake and about a third the distance across from the west shore; the bottom temperature here was 40¼°. About a quarter of a mile south of this point and near the middle of the lake from east to west a depth of 246 feet was found, and the same bottom temperature. A series of temperatures taken August 20 is platted on page 18. The surface of the lake near the inlet at 3 p. m., August 24, was 62° when the air was 70°. The temperature of the east inlet at the same time was 52° and the other was 48°. The water in a small spring creek was 44°.

*Redfish at Wallowa Lake.*—No large redfish were seen at the time of our visit to this lake, August 19–26. From interviews with persons familiar with the region it appears that the large redfish usually reach the lake during the last half of July. They come up the river with the first run of chinook salmon, the run into the lake lasting about three weeks. Soon after entering the lake they are seen in large schools at its upper end. They begin to spawn in September. They are not red when they enter the lake, but become so a short time before spawning. They spawn in the inlets of the lake and on the shores of its upper end. They were formerly caught for the market during the month of August. According to Mr. J. J. Stanley, of Joseph, the run of large redfish in Wallowa Lake in each year since 1882 was as follows:

1883. The run of redfish was very large.
1884. It is estimated that less than 100 redfish entered the lake.
1885. About 75 were caught with a seine, the run being very small.
1886. The run was very large, but not as large as in 1883.
1887, 1888, and 1889. Very few redfish were caught with spears in the river above the lake.
1890. The run was quite large; two parties salted many for the home market.
1891, 1892, and 1893. Very few redfish seen in the lake during these years.
1894. About 2,000 redfish were caught at the head of the lake and salted.
1895. The run was again very small.
1896. The run was very small; about one dozen were seen in the lake and one in the inlet.

In the spring many small fish, from about 6 to 8 inches in length, are stranded in irrigating ditches, many others are killed by entering mill-races. By the inhabitants of Joseph these are thought to be the young of the big redfish on their way to the sea. The large redfish are not known from any streams in this region except in the lake and its outlet and inlets. It is said never to run up the West Fork of the Wallowa River. Only one small redfish was observed while at Wallowa Lake, a small example 5¼ inches long, which was found dead on the lake shore August 24.

According to Mr. Stanley, the small redfish are seldom or never seen there except in September, and then only in schools at the head of the lake or in the inlets where they spawn, at the same time and on the same beds with the large redfish. He says the small ones are called "yanks," and that not more than 1 in 15 is a female; 12 which he caught for us were all males. According to Mr. Stanley, the fish which he calls "grayling" is usually seen only in June, when it is easily caught by trolling in the lake. The small redfish found dead on the beach of Wallowa Lake, August 24, was called a grayling by Mr. Stanley, from which it seems probable, that the so-called "grayling" are the more silvery small redfish.

*Chinook salmon.*—This salmon is known to enter both the West and Main Forks of Wallowa River, the majority running into the West Fork. Those which keep in the Main Fork enter Prairie Creek, where they have their spawning-beds. They have been seen in the outlet close to the lake itself. The early run is in July. The largest run is in September when they are known locally as "dog salmon."

West Fork was examined for a distance of 4 miles, that portion of the river most frequented by chinooks, but no salmon were seen. Four had been caught, however, on the spawning-beds 3 miles above Lostine a few days before, and one was killed by an Indian below Lostine about the same time.

*Steelhead trout.*—The steelhead reaches Lostine on the Wallowa River in March and April. They spawn mostly in the West Fork of Wallowa River, very few being seen in the Main Fork.

## LOWER COLUMBIA RIVER.

It being the desire of the Commissioner to establish a station for the hatching of salmon in the Lower Columbia River basin, we were directed to visit and examine various streams, particularly in the vicinity of The Dalles and Cascades, and select a site suitable for such purposes.

The conditions requisite for such fish-cultural operations as were contemplated are essentially as follows: (1) An abundant supply of salmon easily obtainable when ripe, or nearly so; (2) water of proper quality as to purity and temperature and in sufficient quantity; (3) suitable land upon which to locate the hatchery building, and so situated as to permit the water to be brought to the hatching-troughs by means of gravity; (4) proximity of building materials and good railroad facilities.

Upon taking up this inquiry it became at once evident that no definite information existed concerning the location of salmon-spawning beds anywhere in the Lower Columbia River basin and information regarding the spawning time was equally uncertain and unreliable. It was therefore necessary to visit as many streams as possible and determine the facts by personal inspection and by interviews with people living on or near them.

The telegraphic instructions dated August 1 directed that a site be definitely selected, and as soon as possible, in order that the station might be operated during the season of 1896. In order to be able to examine as many streams as possible in the brief time at our disposal Messrs. Cox and Alexander were ordered from Puget Sound to examine the Lewis River and other streams below Vancouver, while Messrs. Evermann and Hubbard made examinations at the Cascades, The Dalles, Hood River, Big White Salmon, and Celilo. These inquiries were made during the first ten days of August. Later (August 28 to September 6) Messrs. Evermann and Meek examined the Des Chutes, John Days, Hood, Big White Salmon, and Little White Salmon rivers, and on September 7 and 8 Messrs. Evermann and Hubbard reexamined Little White Salmon River and examined Tanner and Eagle creeks near Bonneville. Mr. Hubbard also visited Hamilton and Rock creeks across the river from Cascades, and Mr. Alexander made an examination of Toutle River, Washington. Only the more important results of these various inquiries are given here, detailed reports having been made at the time to the Commissioner.

### LEWIS RIVER.

This river forms the boundary between Clarke and Cowlitz counties, Wash., and flows into the Columbia between Vancouver and Kalama. Two main branches, known as the North Fork and South Fork, unite only a few miles above the mouth of the river. The North Fork has its headwaters on the eastern slopes of Mount St. Helens; the South Fork rises in Skamania County, southeast of Mount St. Helens. No salmon were seen in the North Fork at the time of Mr. Alexander's visit, during the first week in August. It is said that the salmon of the spring run do not enter the river, but that large numbers of chinook salmon of the fall run enter it; also a good many silver salmon and steelheads. The chinooks are said never to run in until after the 10th of August, when the close season begins. When the close season ends (September 10) fishing with gill nets and seines is carried on to some extent in this river. Some logging is carried on in this stream during the spring, but it ceases long before the salmon arrive.

Considerable spawning-beds are said to be located in the vicinity of Ætna. The water is pure and cold, and if chinook salmon really come there in large numbers all other conditions are favorable for fish-cultural purposes.

The South Fork was examined as far up as La Center. This stream is about the same size as the North Fork, but the water is not clear. The banks, in the lower portion at least, are composed of red clay or easily disintegrated rock, and the water is thus usually kept more or less muddy. Below La Center there seems to be no bottom suitable for spawning-beds and there are no tributary creeks from which water suitable for hatchery purposes could be obtained. Chinook salmon of the fall run are said to enter this fork, but the locality of their spawning-beds is not known. No salmon were seen by Professor Cox at the time of his visit.

### TOUTLE RIVER.

This stream is an eastern tributary of the Cowlitz, into which it flows a few miles north of Castle Rock. About 11 miles above its mouth is a fall 15 feet high. From this point down there are many riffles suitable for spawning-beds, and where racks could be put in without difficulty. One of the best places is at the mouth of Pat's Creek, about 7 or 8 miles above the mouth of the river, where the stream is 35 to 75 feet wide and the bed is of coarse sand and gravel. Suitable water for hatchery purposes could be obtained from the creek.

It is claimed that the fall run of salmon enters this river in considerable numbers, including chinook, silver, dog, humpback, and steelhead. Salmon appeared to be scarce at the time the river was examined, as only three were seen by Mr. Alexander; but it was stated that they would be more abundant about the 1st of September. They are said to collect in numbers at the foot of the falls already alluded to, and if this be true, that would prove a good place for collecting the eggs. The falls do not seem to offer an impassable barrier, as salmon are reported from points still farther up the stream.

### CASCADE LOCKS.

On the Washington side of the Columbia River, opposite Cascade Locks and at the head of what is known as the "Old Incline" at the Upper Cascades, is a place where it was thought fish-cultural operations might be carried on successfully. The fish would have to be caught in wheels, several of which are operated in the vicinity, and held until ripe in a retaining channel or pond. This channel has sufficient water flowing through it, can be easily racked at each end, and seems in every way fairly well suited for such a purpose. There is a good site for the buildings and sufficient water is obtainable by gravity from a small creek near by. It is claimed that an abundance of salmon can be obtained by running the wheels in August and September and that they will be so nearly ripe that retention in the pond or channel will be necessary for only a short time.

An effort was made in August to transport fish caught in these wheels to the retaining pond, but it proved a failure. Whether due to lack of care and skill in making the transfer, or to inherent difficulties, is not certain, but we believe there is no good reason why salmon may not be safely transferred at this place. We question, however, whether they would live in the retaining pond until ripe, unless the pond be rather deep and kept dark.

## CELILO.

Mr. A. B. Alexander was directed by the Commissioner to visit Celilo, Oreg., for the purpose of watching the daily catch of fish taken there in wheels. He arrived there September 17 and remained till September 23. His report is in substance as follows:

Only one wheel was in operation September 17. Two others close by were not running, owing to low water. It was expected to pack 4,000 cases, but by September 23 less than 1,000 cases had been packed. The fall run of salmon was very light in nearly all parts of the river. The accompanying table will show the daily catch for one wheel, with their condition, etc.:

| Date | Steelhead. | | | | | | | Chinook all caught in wheel. | | | | | Silver all caught in wheel. | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Total catch. | Number of males. | Males nearly ripe. | Number of females. | Females nearly ripe. | Caught in wheels. | Caught by Indians. | Total catch. | Number of males. | Males nearly ripe. | Number of females. | Females nearly ripe. | Total catch. | Number of males. | Males nearly ripe. | Number of females. | Females nearly ripe. |
| 1896 | | | | | | | | | | | | | | | | | |
| Sept. 18 | [illegible] | 111 | 10 | 124 | 15 | [illegible] | 75 | 28 | 19 | 10 | 9 | 9 | 6 | 5 | 2 | 1 | 0 |
| 19 | 24[illegible] | [illegible] | [illegible] | [illegible] | 22 | [illegible] | 60 | 1[illegible] | 8 | 5 | [illegible] | 6 | 8 | 6 | 4 | 2 | 1 |
| 21 | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | 53 | 1[illegible] | 11 | [illegible] | 26 | 22 | 9 | 7 | 13 | 8 |
| 22 | [illegible] | [illegible] | [illegible] | [illegible] | 164 | [illegible] | [illegible] | 20 | 12 | 8 | 8 | 6 | 19 | 11 | 8 | 8 | 6 |
| Total | 1,512 | 521 | 136 | [illegible] | [illegible] | [illegible] | [illegible] | 119 | 57 | 34 | 62 | 47 | 55 | 31 | 21 | 24 | 15 |

Among the 119 chinooks, 13 were small males, with their milt as fully developed as that of the large fish. The wheels sometimes take these fish in considerable numbers. The Indians prize them highly and seldom offer one for sale. Those examined were quite uniform in size, few weighing over 4½ pounds, the minimum being about 3 pounds. In length they vary from 12½ to 23 inches. Their color is very dark, the spots not being visible a distance of 10 feet. On closer inspection all the marks of a large chinook are visible. Fishermen usually do not class this fish with the chinook, but think it a different species.

The chinooks taken in the fall of 1896 at Celilo were said to be somewhat larger than those for several years past, the average weight being 20 pounds; average length, 37 inches; greatest length, 43 inches. The average was about 1 pound larger than the usual fall run, and 1 pound less than the spring fish.

The steelhead varied in length from 25 to 42 inches, the average weight of those taken at Celilo being 18 pounds. A few weighed from 35 to 37 pounds. On first coming from the water the steelhead is very bright-colored, the large specimens having a bright stripe extending along the sides the whole length of the body, varying from a light pink to a deep bronze. The colors are very pronounced when the fish is first caught, but grow dim on being exposed to the air.

Silver salmon are from 18 to 30 inches long; their average weight is 7 pounds.

Early in the fall Seufert Bros. operated three wheels, but two of them could not be run after the river had fallen. Mr. Taffe's wheel was adapted to low water. An island lying between Celilo and Tumwater is exposed when the river is low, the

water on the south side of the river flowing over a rocky ridge forming falls some 12 or 15 feet high. Many salmon find their way to the foot of the falls and endeavor to ascend them and when the water is about half low many succeed, but when the distance from the lower to the upper current of water is from 8 to 10 feet thousands of salmon at times may be seen jumping into the whirlpools at the foot of the falls. Just above the falls are two wheels, the larger on a rocky point projecting into the river. When the river is high, many of the salmon pass by this point over that part of the river where the falls are during low water. The wheel here catches fish only when the water is high; the other wheel, at the head of a channel, takes fish when the water is low.

The wheels in operation during the fall months are built in places where the water is deep and the current swift. There being few natural places in the vicinity where wheels can be successfully operated, long deep channels have been cut through the volcanic rock and the water led into them. At or near the head of these artificial channels the wheels are built. The water rushes through the channels with considerable force, offering a strong inducement for salmon to enter. On arriving at the foot of the falls and finding it impossible to go farther salmon naturally enter the channel which leads to the wheel. If the water is very clear, the fish will congregate in large numbers in pools and eddies near the mouth of the channel and at the foot of the falls, remaining there for days without attempting to go up the channel. Sometimes several thousand fish will crowd themselves into the mouth of the narrow channel and remain there for hours at a time. Suddenly, as if by one impulse, they will dart up channel, and are soon caught up by the revolving wheel and landed on the platform in the fish-house.

Wheels are built in places near high-water mark where salmon are known to run in greatest numbers. The migratory habits of all species of salmon visiting the Columbia River in the vicinity of The Dalles are said to vary from year to year. This often causes a considerable expenditure of money in wheels frequently followed by negative results. For several years the main run of salmon may pass certain points in the river, when suddenly a new route will be selected. This change often transfers the best fishing-ground from one side of the river to the other, and wheels which have made large catches one season prove a failure the next. Only those with long experience in this locality are competent to select good sites for wheels. Several wheels on the river, built at a cost of from $3,000 to $5,000, have never taken a fish. This method of fishing requires considerable capital.

On September 18 and 19 a large number of fish, mostly steelheads, were noticed to ascend the falls, but, as the river was falling rapidly, in a short time they were prevented from taking their natural course and were forced either to enter the channel or remain in the pools or eddies at the foot of the falls. At this time the wheel at Celilo began to take more fish than it previously had, the daily catch increasing during the time Mr. Alexander was there. The catch of chinook and silver salmon was small as compared with the number of steelheads. The last-mentioned species is always found in greater numbers at this season, the fall run of chinook being limited in number. Only a few silver salmon are caught here.

This season, owing to the unusual scarcity of fish at Celilo, the cannery there did not put up any spring fish, the run being very small. The great bulk of salmon was taken in wheels below the Cascades. Arriving at this point, they seemed inclined to go no farther up, and the canneries in that locality made large packs. Fish expected

at The Dalles in the spring did not appear until about the close season. A large body of steelheads passed up the river during that time. Ordinarily the run of steelheads arrives at The Dalles early in September, but this year most of the run passed by during the close of the season.

On September 18 the wheel at Celilo took 160 steelheads, 28 chinook, and 6 silver salmon, and 75 steelheads were taken by Indians with spears and dip nets. Of the steelheads, 111 were males and 124 females; 10 males and 15 females were in an advanced stage of development, and would have been ripe in a comparatively short time; the rest of the catch would not have been ripe until late in the season. Of the chinooks, 19 were males and 9 females; 10 males and all of the females would have been ripe by about the first week in October.

During the five days spent at Celilo 1,512 steelheads, 119 chinook, and 55 silver salmon were examined. Of the steelheads, 991 were females and 521 males; 299 females and 126 males showed considerable signs of development, and would have been fully ripe by the first week in October.

As the river falls many places are left bare where salmon were caught earlier in the season. Sharp rocks are exposed, small peninsulas formed, and rocky islands appear where a few months before there was nothing to indicate their presence except an occasional small whirlpool or riffle. At such places Indians fish with spear or dip net. Each fall several tribes from various parts of the State camp at Celilo and Tumwater, remaining there until the season is over. They fish for the canneries principally, but also lay in a supply of salmon for themselves. In pleasant weather when salmon are plentiful they do a lucrative business. Sometimes one man catches 35 salmon in a day. Their fishing is with a dip net and detachable gaff hook and is carried on in swift water, the men standing on overhanging rocks or shelving places where a foothold can be had. This is dangerous work, and not a few lives have been lost from time to time. When the wind is high, one of the strong gusts that frequently sweep the river may suddenly strike a fisherman unprepared to receive it and blow him into the river. Each fisherman who stands in a dangerous place therefore has a rope fastened around his waist and secured to a rock.

In the whirlpool of water only an occasional fish can be seen and the fisherman stands and dips blindly. Sometimes a hundred dips or more will be made without a fish being taken, at other times one will be caught at almost every dip. Where the water is less turbulent salmon are taken with spears, each spearsman having his particular standing-place, from which he keeps a vigilant watch, few salmon escaping that approach within throwing distance.

The Indian is assisted by the women and children of the tribe, who gather the fish when caught, throwing them into a pile on the rocks and rendering such other assistance as may be required. As soon as the day's fishing is over the Indian leaves the fish to be taken care of by the women, and they are taken from the island to the mainland, and carried in baskets over a steep, rocky path to the cannery, a distance of about a third of a mile. When there is a good catch many trips are required to be made to the cannery. A male Indian seldom does this kind of work; he is quite willing that it should be performed by the women, and raises no objection when young girls are pressed into the service by their mothers. Sometimes, however, small boys lend assistance, but by the time they arrive at the age of 12 they have caught the spirit of their elders and refuse to do woman's work.

When salmon are plentiful an Indian can earn from $5 to $8 a day. The price varies from year to year, according to the supply and demand for salmon by the canneries. This season 2 cents a pound was the standing price for chinooks and steelheads. Indians consider the chinooks superior to all other salmon, and it is only when plentiful that they are sold to canneries. No part of this fish is thrown away; the ripe eggs and even the tail, head, and fins are eaten.

The dwarf chinooks, previously spoken of, not being used by canneries, are greatly sought after by the women of the tribes, who squat on the floor of the room where the fish are dressed, patiently waiting for the small fish to be culled out. They sit for hours shivering in the cold, and consider themselves well paid if each receives one or two fish. During the fishing season the women and children congregate in the dressing-room, waiting for a share of the heads, tails, and fins as they fall from the butcher's knife.

The ripe eggs of chinook salmon are considered a great delicacy and are gathered in large quantities. They are first separated and then dried in the sun, after which they are prepared in various ways as food.

Steelheads swim near the surface and are more easily caught than the chinooks, which swim deep. Clear water influences the catch; if the water be clear the catch is less than when it is muddy.

From September 25 to the 13th of October 2,667 steelheads, 1,402 chinooks, and 2,213 silver salmon were examined at Celilo; 1,010 of the steelheads were males and 1,657 females; 683 of the chinooks were males and 719 females; of the silver salmon, 1,011 were males and 1,202 females; 350 male steelheads and 601 females were in an advanced stage of ripeness; also 574 male and 528 female chinooks, and 843 male and 1,048 female silver salmon.

The eggs and milt of the salmon caught during October were somewhat further advanced than that of those examined in September at Celilo. A large part of the eggs of the chinook on being taken from the fish would immediately separate; this was also true of many of the silver salmon and steelheads. A number of the latter showed no signs of development, but many were well advanced and some about ready to spawn. It would seem that the spawning season of the steelhead extends over a greater period of time than that of other species. A careful examination carried on in other streams would no doubt throw more light on the subject.

In the fall, after the close season, a seining "gang" of twelve to fifteen men goes into camp on a long pebbly beach, about a mile below the fishing station at Tumwater. This season two seines were operated on the Oregon side of the river and one on the Washington side. At times fish will be found plentiful on one side of the river and few on the other, when suddenly, without apparent cause, they shift to the opposite side.

During the fishing season seining is carried on with little or no interruption, hauls being made in quick succession all through the day. The seines are set from a flat-bottom boat, one end of the seine rope being held on shore by horses while the net is being thrown out. As soon as the net is set the seine rope on the lower end is picked up by other horses and the hauling-in commences. It would be impossible to land the net by hand, so swift is the current, and frequently the united strength of four horses is barely able to land it. At each haul the fish caught are loaded into wagons and taken to the fishing station, where they are weighed, washed, and put into cars. If they are to be canned they are thrown into the car in bulk; if shipped east, they are

packed in boxes and iced. In the early part of the fall season the demand for fresh steelheads is large, and there is more profit in shipping fish east than in canning them.

The only place noticed near Tumwater where salmon could be held for spawning purposes is near the seining-ground on the Washington side of the river. Here a channel has been cut, but owing to the small number of fish that entered it the wheel built near its head and also the channel have for several years been abandoned. On the lower end of the channel is a small indentation where an eddy is formed; a dam could be built here and also one across the mouth of the upper end of the channel, with iron screens at either end. By covering the top of the channel, either the whole or a part of it, an inclosure would be formed which would hold a large number of salmon. It seems reasonable to suppose that salmon would live much longer in an inclosure of this kind than in boxes, as they would be crowded far less and have a better circulation of water. A swift current or comparatively still water could be had by putting in a gate at the upper end of the channel. The cost would be considerably more than keeping salmon alive in cars or boxes, but it is thought that the results would be more satisfactory.

### SEUFERT'S TUMWATER.

On the Washington side of the river, opposite Seufert Brothers' cannery, is an excellent seining-ground, where salmon are said to be caught in large numbers. Within a few rods is a narrow channel of the river suitable in every way for a retaining pond. The hatchery building could be placed upon ground quite close to the retaining channel and where a supply of suitable water can be led by gravity. Seining is carried on principally for silver salmon and steelheads; many chinooks are also caught, but they are so near the spawning condition that they are not used for canning. The probabilities that fish could be secured here and retained for a short time until ripe are greater than at the Cascades, and the expense would be very slight.

### JOHN DAY RIVER.

This river was examined at its mouth September 2. It is there a stream of moderate size, quite shallow, and very muddy. The banks and bottom for some distance above the mouth are of mud or sand. Farther upstream the water is, of course, much clearer. Salmon could doubtless ascend the John Day River, but it is not certain that they do so in any numbers, and none was observed. Interviews with persons living on or familiar with the upper course of the stream failed to elicit any evidence that chinook salmon are now found there. It is said that a good many salmon formerly entered this river and spawned in the spring, but these are evidently steelheads and not chinooks. A few years ago a wheel was operated in the mouth of the John Day, but it has not been run for two or three years.

### DES CHUTES RIVER.

The Des Chutes River has its source on the eastern slopes of the Cascade Mountains and elsewhere in Crook County, Oregon, flows nearly north and joins the Columbia about midway between the mouth of the John Day River and The Dalles. It has been generally regarded as the best salmon-spawning stream in the lower Columbia basin, and it was reported that large numbers of salmon can be seen at any time in the fall in this river at Sherar's Bridge, 30 miles from The Dalles or about 40 miles above the mouth of the river. This place was therefore visited from August 29 until September 1.

Throughout the lower portion of its course this river has cut a narrow, deep channel in the lava beds. The canyon's walls are so abrupt that it is impossible to reach the river in many places. At Sherar's Bridge the canyon widens out a little and the river here has a fall of 8 or 10 feet. Below the falls the river is compressed into a very narrow gorge, through which the water rushes with much fury. At the bridge the water is said to be 86 feet deep, which is about equal to the river's width at that point. Immediately above the falls the river widens out greatly and is very shallow for some distance.

Until within the last six or eight years "salmon" were seen here every spring in considerable numbers. Mr. J. H. Sherar, who has lived at these falls for many years, says "salmon trout" were present throughout the year, but were not abundant except in the spring, and that they spawned in the spring; they had no difficulty in ascending the falls, and his understanding has always been that many of them went far toward the headwaters to spawn. Formerly Mr. Sherar caught large numbers of these salmon trout, but he has seen but very few for four or five years.

Several persons who live on the upper course of the Des Chutes, report that formerly a good many "salmon trout" were seen there in the spring, which was their spawning time, but that few if any have been noticed for several years. It would appear that the chinook salmon has never run into the Des Chutes in large numbers and that few enter it now; that the fish which at one time was rather abundant is the salmon trout or steelhead, *Salmo gairdneri*. The spawning-beds in this river are too remote from the railroad to be available for fish-cultural operations.

### HOOD RIVER.

This stream is fed chiefly by the snows and glaciers of Mount Hood and flows into the Columbia at Hood River Station. It does not appear to ever have been frequented by chinook salmon in large numbers. The people at Hood River Station do not think that many salmon enter this river, and persons living several miles up the river say that salmon are seen there but rarely.

### BIG WHITE SALMON RIVER.

This river was examined August 6, and again on September 4. It is a stream of considerable size, having its sources on the western and southern slopes of Mount Adams. It flows in a general southerly course and empties into the Columbia nearly opposite Hood River Station. It is, in its lower course at least, a rough, turbulent stream, full of rapids and large bowlders, and flowing between high, and, in some places, precipitous, banks, so that it is difficult to reach the edge of the stream. At the mouth of the river the canyon widens out and there is a little level land along the stream. In August all of this was flooded by back water from the Columbia, but in September it was dry. No salmon were seen on our first visit, but on September 4 quite a number were observed jumping in the Columbia about the mouth of the tributary stream. On that date Indians had established two camps at the mouth of the river for the purpose of taking salmon during the season. They go up the stream from a quarter of a mile to a mile and capture the salmon by means of gaff-hooks on the ends of long poles. Only four salmon were taken during an afternoon. While the conditions are not favorable for operating a hatchery on this river, a good many eggs could probably be obtained and carried to any station which may be established on the lower Columbia.

### LITTLE WHITE SALMON RIVER.

This stream enters the Columbia about 6 or 8 miles below the mouth of Big White Salmon River. It was examined September 5 and 7, and the prospects for successful salmon-cultural operations appeared so good that a site at the mouth of the river was selected and preparations begun at once for equipping the station. Salmon were already in the stream in large numbers and spawning had begun. By the time the station was ready to begin operations the height of the spawning season had arrived, but more than 2,000,000 eggs were taken, and it is believed by Mr. William P. Sauerhoff, superintendent of the station, that 10,000,000 eggs could have been obtained if operations had begun earlier in the season. The success attending the operation of this station is highly gratifying. Up to the time of writing these lines (October 30, 1897) the total number of eggs taken at the Little White Salmon Station this season is over 12,500,000.

### TANNER AND EAGLE CREEKS.

These are two small streams flowing into the Columbia at Bonneville, Oregon. The smaller is Tanner Creek, whose mouth is only a few rods west of the railroad station. It was examined September 7 by Messrs. Evermann and Hubbard, who found about 300 chinook salmon in the stream within a mile of its mouth. Most of the fish were lying quietly in deep holes, but some were in shallow water and evidently spawning.

The mouth of Eagle Creek is about half a mile east of Bonneville. This stream is considerably larger than Tanner Creek. Its bed is exceedingly rough and rocky, and only with much difficulty can salmon ascend it. A large bunch of salmon were lying in the deep hole under the railroad bridge and a few others were seen a short distance farther up the creek. Though these creeks are small, from 1,000,000 to 2,000,000 eggs could probably be taken there annually and carried to the Little White Salmon Station.

Across the river from Bonneville, and only a short distance below Little White Salmon River, are several streams into which salmon are said to run. Among these are Little Wind River, Wind River, Smith Creek, Rock Creek, Hamilton Creek, and Hardy Creek. Some of these are unsuitable for salmon on account of large quantities of wood which are floated down, and bars sometimes form across the mouths of others, especially Hamilton and Hardy creeks, so that salmon are not able to enter; but usually a good many salmon spawn in these creeks, and doubtless a great many eggs could be collected from them. Their proximity to the Little White Salmon will make it easy to carry the eggs to that station.

### PUGET SOUND.

In connection with the work of the joint commission appointed to investigate the fisheries of the contiguous waters of the United States and Canada, certain investigations were made by Messrs. Alexander and Cox concerning the movements of the sockeye or blueback salmon in Puget Sound and its tributary streams. The information obtained has been furnished to the joint commission and has been used in its report. The movements of the sockeye in the north end of the sound were studied, particularly among the San Juan Islands, chiefly to determine whether many of that species run into streams flowing into the sound from the State of Washington.

The principal rivers examined were the Nooksack, Skagit, Stillaqualmish, and Snohomish. The time was too short to permit an exhaustive study of the questions involved, but enough was done to show that most of the rivers flowing into Puget Sound from the east are salmon streams of considerable importance. This is particularly true of the Skagit. The sockeye runs into this river in large numbers, and there are important spawning-beds of this species in its headwaters. The State of Washington has recently established, and is now successfully operating, a hatchery for this species on Baker Lake, one of the upper tributaries of the Skagit.

The height of the run of sockeye salmon in 1896 at the San Juan Islands was from August 20 to 28. The run was regarded as unusually large in view of the fact that this was an off year. Nothing definite was learned regarding the occurrence of the sockeye in any streams except the Skagit, nor whether it is found in any of the upper tributaries of the Skagit except the Baker. The Baker River has a lake in its upper course which can be reached by the sockeye.

So far as is yet known, this species spawns only in such streams as have lakes at their headwaters, and the spawning-beds are found only in the streams tributary to the lakes or in the lakes themselves. Several streams tributary to the northern part of Puget Sound contain lakes in their headwaters, and it would prove interesting and valuable work to determine accurately the distribution of the sockeye in this region.

All the other species of west coast salmon are found here in large numbers. The chinook first appear, then the silver salmon and steelhead, and still later the humpback and the dog salmons. The Nooksack is the principal river frequented by these species. The silver, humpback, and dog salmons are said to ascend both forks of this river.

The actual or even relative abundance of the different kinds of salmon and their distribution in the rivers of western Washington is not well understood, and scarcely anything is known regarding them after they enter the rivers.

## LAKE WASHINGTON.

In February, 1889, the United States Fish Commission planted 375,000 fry of the common whitefish (*Coregonus clupeiformis*) in Lake Washington at Seattle. In June, 1896, Mr. A. B. Alexander visited this lake and began a series of observations for the purpose of determining the results of this planting of fish. After a few observations he was called away to other work, but returned and again took up the inquiry November 23, continuing it to January 10 following.

*General description of Lake Washington.*—This lake is situated in King County, Washington. Its greatest length, which lies nearly due north and south, is 18½ miles, and its greatest width, from Mercer Slough across Mercer Island to the west shore, is about 4¾ miles. The greatest width of open water is about half a mile north of Mercer Island and is 3½ miles. The narrowest channel lies between Mercer Island and a point on the east shore about ¾ of a mile north of Mercer Slough. The city of Seattle is situated upon the west shore about equally distant from the north and south ends of the lake. There are numerous bays and indentations, which give the lake a total shore-line of about 58 miles. The lake has an elevation of 34 feet above low tide at Seattle. The principal outlet is Black River, at the extreme southern end of the lake. This river is 2½ miles long, and unites with White River to form Duwamish River, which flows into Elliott or Duwamish Bay a short distance south of Seattle. About a half mile below the lake Black River receives the Cedar River from the east.

A few years ago a channel was cut from Union Bay through Lake Union to the sound. Considerable water flows through this channel and small boats are able to pass through it.

At the north end Lake Washington receives Squak Slough, which is the outlet of Lake Sammamish. This slough runs in a tortuous channel through low, marshy ground, its width varying according to the height of water in the lakes which it connects. When the water is very high the slough overflows and covers the low land on either side.

During heavy rain the Duwamish River is unable to carry off readily all the water brought down by the White, Cedar, and other streams, and as a result Black River becomes, for the time being, an inlet instead of an outlet of Lake Washington. The lake therefore rises perceptibly, the inflowing water from Lake Sammamish is held back, and Squak Slough overflows the adjacent lowlands.

Lake Washington is a beautiful body of water, surrounded by high hills from which a fine view of the surrounding country may be had. The Cascade Mountains are plainly seen to the eastward and on the south Mount Ranier comes into conspicuous view. In many places steep banks make down to the water's edge, indicating deep water. Nearly all the hills are covered with a dense growth of trees, except where clearings have been made for homes and settlements. The shore line in nearly all parts is fringed with a dense undergrowth of brush and small trees; tule grass is found at every low point and slight indentation. Small trees along the shore interfere with the hauling of seines, and only limited collections can be made. In November and December a large amount of decayed vegetation covers portions of the shore. In summer various forms of minute animal and plant life inhabit the water.

*Seine-hauling grounds.*—Only in a few places along the shore of the entire lake is the bottom sufficiently free from snags, fallen trees, and other material to permit the successful hauling of nets. On the west side of the lake, about 2 miles above Union Bay, is a long stretch of sandy shore mixed with fine gravel; in June, 1896, several attempts were made to haul a seine here, but on account of the many obstacles no fish were taken. On the east side, at Hunter Point, is a comparatively good ground, but tule grass grows in considerable quantities, though by wading out and bending it down where the seine is to be landed fairly good results can be obtained. Several hauls were made here and a number of fish taken. In fall and winter there is a great scarcity of life here, as several trials demonstrated. From Hunter Point southward for about $2\frac{1}{2}$ miles the shore makes down to the lake with a gradual slope, but owing to the great amount of vegetation that extends in most places into the water, it is almost impossible to use a seine. This also may be said of Mercer Slough and the shore farther south. On the east side of Mercer Island the bank is usually quite steep; on its west side the land is more sloping. The water all round the island is deep. In the extreme southern portion of the lake, in the vicinity of Renton and Black River, the land is marshy and filled with small sloughs. The bottom is of soft mud.

On the north and west sides of Lake Washington, from Webster Point to Sand Point, are scattering sandy patches, but only in a few places can a seine be hauled, owing to a thick growth of scrubby trees at the water's edge. High banks in most places overhang the shore line. Northward from these points the land is more sloping and in some places comparatively level. Rocky and gravel beaches crop out from the banks in many places and in a number of indentations the water makes off shallow

from the shore a distance of 50 feet or more. The bottom here is very muddy and covered with tule. The shore on this side of the lake is thickly strewn with logs, slabs, and small floating débris. Few rocks are noticeable, and none at any great distance from shore.

The sandy and gravelly beaches referred to on the west side of the lake below Sand Point are usually narrow; only in one place observed is the beach over 10 feet wide; here the width from the water's edge to the bluff is about 30 feet. The clear ground indicates a smooth bottom, but stumps of trees and broken limbs prevent seine collecting. These beaches are formed by wave action, the water having washed away the base of the bluffs, leaving a deposit of sand and gravel. In many places, particularly on the west side of the lake, bushes and small trees have taken root in the sand and gravel deposit. Only in a few instances does the sand and gravel formation extend any great distance below the water's edge; 30 or 40 feet from the shore is soft muddy bottom. As is indicated by the high perpendicular bluffs, the beaches make off at a sharp angle, deep water being found a short distance from the shore. As a whole, the shore of Lake Washington is not well adapted to collecting with a seine.

*Depth and character of bottom.*—Soundings were taken at different times and in various parts of Lake Washington. It has a uniform depth in the center, ranging from 138 to 222 feet. The character of the bottom is generally muddy. Off the mouth of Union Bay and near the boathouse at Madison street sandy bottom was found. Off and in the vicinity of Sand Point, 3½ miles farther north, the bottom is composed of sand and gravel. This kind of bottom does not extend very far from the shore, from 500 to 800 feet being about the limit. For nearly 2 miles south of Sand Point there are a number of sandy places along the shore, mostly covered with an undergrowth of bushes. In all other parts of the lake examined the bottom is chiefly of soft mud. On the east side of the lake, south of Hunt Point, the water is quite deep close to the shore; this is also true of the west side, south of Sand Point, and in many other parts. A depth of from 500 to 1,800 feet was reported off the northern end of Mercer Island and in the vicinity of Hunt Point. Comparatively deep water was found off these points, as will be seen by referring to the map, but no such depths as had been reported. About 1 mile along the shore above Kirkland a plateau from 60 to 100 feet wide, covered with vegetation, makes off from the shore. The water varies in depth from 10 to 20 feet, but suddenly deepens into 60 and 70 feet when the edge is reached.

*Temperature of water.*—It will be noticed in the table of temperatures that near the shore on the east side of Mercer Island the temperature of the water at the surface varies considerably from that taken a short distance toward the middle of the channel. A difference of 2½° is recorded, the bottom temperature in both soundings being the same. In no other part of the lake was such a marked difference found. Several tests of the water were made within a radius of 100 feet or more, all with the same result. A few hundred feet from this position, to the north, south, or east, 47° was found at the surface. It is said that thermal springs occur in this vicinity in a number of places. The temperature of the water at the bottom, however, does not indicate their presence. The lowest temperature found in the main body of the lake was 44½°, and the highest 48½°; the first in depths of 180 and 190 feet. In Union Bay, in 14 feet of water, a temperature of 41° was recorded both at the surface and the bottom. This low temperature was due, no doubt, to the cold weather, which at this time was quite severe. At no other place was such a low temperature found.

The temperature of the air seemed to have no perceptible daily effect on the water in deep portions of the lake. From November 23 to 30 the air varied but little, from 20° to 29° being about the minimum and maximum height. During December from 45° to 48° was the approximate daily temperature.

In depths over 150 feet the air ceased to have an effect on the water much below 40 feet from the surface. In a few places 50 feet below the surface was reached before the temperature remained constant. In depths less than 100 the temperature was found constant about 30 feet below the surface.

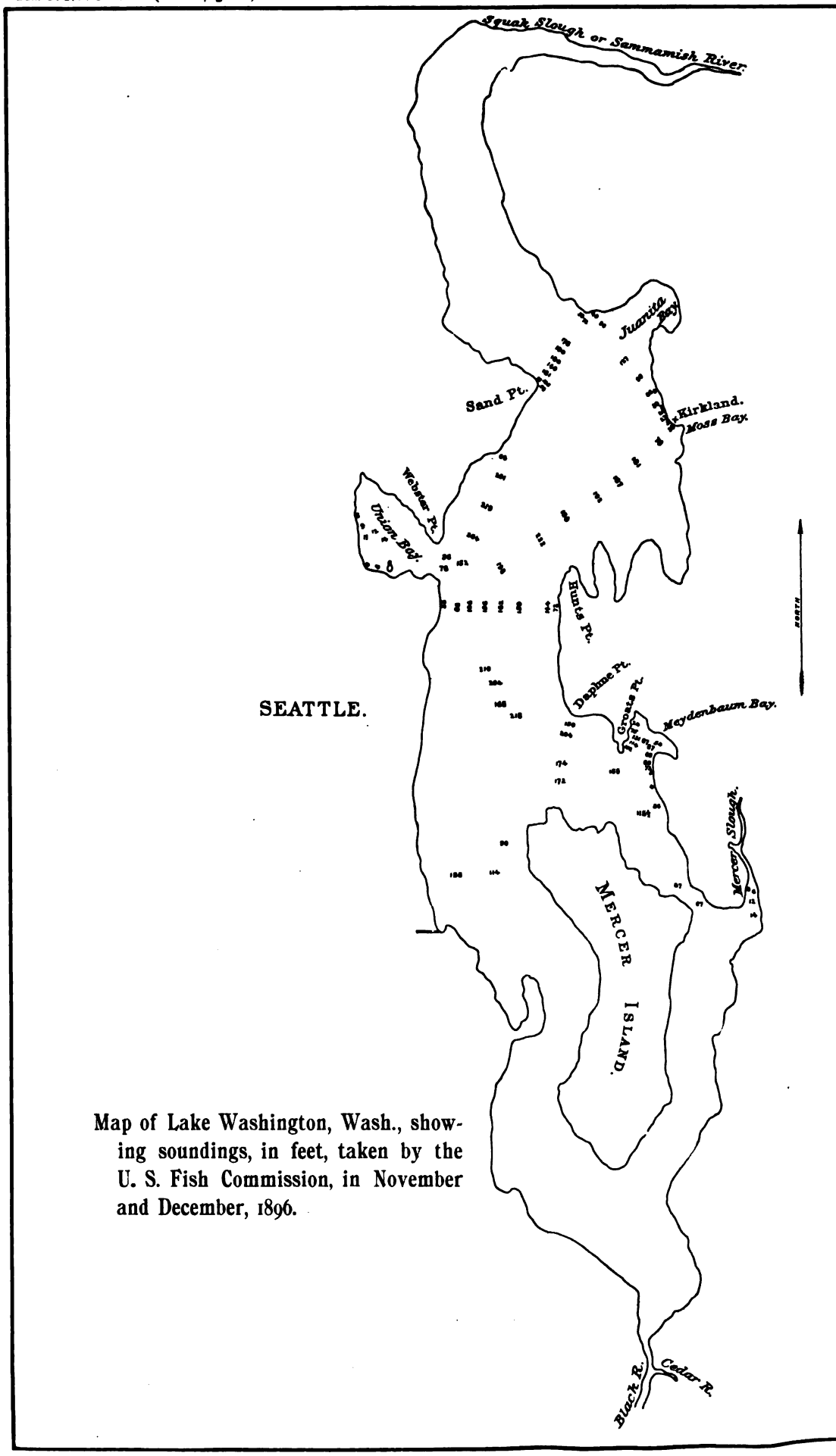
It will be noticed that in a number of places in depths ranging from 40 to over 200 feet the temperature both at the surface and bottom is the same. Why this should be, when only a short distance away the difference between the surface and bottom is a degree or more, is not easily explained.

Many of the temperatures and soundings taken are recorded in the following table:

*Soundings and temperatures taken in Lake Washington.*

| Date. | Depth. | Temperature at surface. | Temperature at bottom. | Position. | Date. | Depth. | Temperature at surface. | Temperature at bottom. | Position. |
|---|---|---|---|---|---|---|---|---|---|
| | *Feet.* | ° F. | ° F. | | | *Feet.* | ° F. | ° F. | |
| Nov. 23 | 35 | 48½ | 48½ | 300 feet from shore, near Madison-street boathouse. | Dec. 19[a] | 50 | 49½ | 46 | Close to shore east side of Mercer Island. |
| 24 | 14 | 45 | 44 | In various parts of Union Bay, which is a part of Lake Washington. | 19 | 58 | 47 | 46 | 300 feet from shore and near last sounding. |
| 24 | 10 | 45 | 45 | | 19 | 67½ | 47 | 46 | Halfway across channel between Mercer Island and east shore. |
| 25 | 98 | 48 | 48 | One-fourth mile east of boathouse. | 19 | 55 | 47 | 46 | Near the east side of lake. |
| 25 | 156 | 48 | 47 | One-fourth mile east of last station. | 19 | 12 | 46 | 45 | Close to shore. |
| 25 | 162 | 48 | 47 | Middle of lake. | 20 | 70 | 46 | 46 | Half a mile north of last sounding. |
| 25 | 150 | 48 | 47 | Two-thirds across lake. | 20 | 87 | 46 | 46 | One-eighth mile west from last sounding. |
| 25 | 144 | 48 | 47 | One-eighth mile from east side of lake. | 20 | 115½ | 46 | 47 | Halfway across east end Mercer Island to east side of lake. |
| 25 | 72 | 48 | 48 | 300 feet from shore. | 20 | 174 | 46½ | 46 | Halfway between Daphne Point and north end Mercer Island. |
| 27 | 14 | 41 | 41 | In Union Bay; cold weather, air 28° and 30°. | 23 | 204 | 46½ | 45½ | Half a mile east Webster Point. |
| 27 | 98 | 47 | 44 | Off mouth Union Bay. | 23 | 219 | 46½ | 45½ | Half a mile north last sounding. |
| 28 | 150 | 47 | 47 | Do. | 23 | 201 | 46½ | 45½ | Half a mile northward last sounding, ¼ mile from shore. |
| 28 | 152 | 47 | 47 | Do. | 23 | 66 | 46 | 46 | Third of mile north and close to shore. |
| Dec. 1 | 96 | 47 | 47 | Do. | 23 | 58½ | 46½ | 46½ | About 500 feet from Sand Point south near shore. |
| 1 | 168 | 47 | 47 | 1½ mile SSE. from Madison-street boathouse. | 23 | 105 | 47 | 46 | About 200 feet from Sand Point NE. |
| 1 | 90 | 47 | 47 | 1½ mile east from Yesler-street boathouse. | 23 | 181 | 46½ | 45½ | Less than ½ mile NE. from last sounding. |
| 1 | 114 | 47 | 46 | Two-thirds across lake from pumping station to Mercer Island. | 23 | 168 | 46½ | 45 | Less than ½ mile in same direction. |
| 1 | 156 | 47 | 46 | One-half mile off waterworks. | 23 | 180 | 46½ | 44½ | About the same distance farther on. |
| 18 | 210 | 46½ | 46 | One mile SE. from Madison-street boathouse. | 23 | 190 | 46½ | 44½ | Less than ½ mile NE. last station. [a] |
| 18 | 204 | 46 | 46 | One-fourth mile SE. from Madison-street boathouse. | 23 | 178 | 46½ | 45½ | Last deep sounding on this line. |
| 18 | 218 | 46½ | 46 | 1½ mile SE. from Madison-street boathouse. | 23 | 72 | 46 | 46 | Near opposite shore from Sand Point. |
| 18 | 204 | 46½ | 46 | One-third of a mile SW. of Daphne Point. | 23 | 96 | 46 | 46 | About 1,500 feet from shore. |
| 18 | 150 | 46 | 46 | One-eighth of a mile SW. of Daphne Point. | 23 | 129 | 46 | 46 | About halfway from last station to Kirkland. |
| 18 | 156 | 46 | 46 | One-third mile off Meydenbauer Bay. | | | | | |
| 19 | 114 | 46 | 46 | Near middle of Meydenbauer Bay. | | | | | |
| 19 | 69 | 46 | 46 | South side of bay. (Other soundings taken in bay; same temperature.) | | | | | |
| 19 | 12 | 47½ | 47 | Short distance south of Meydenbauer Bay. | | | | | |
| 19 | 40 | 47 | 47 | One-third mile farther south near shore. | | | | | |

[a] Said to be thermal springs in near vicinity, which may account for the change of temperature.




Map of Lake Washington, Wash., showing soundings, in feet, taken by the U. S. Fish Commission, in November and December, 1896.

During the winter months short periods of cold weather sweep over this part of the Northwest, but not sufficiently severe for ice to form in the main portion of Lake Washington. Occasionally skim ice appears on the margin of the lake in sheltered places covering small areas.

*Trials with gill nets and other apparatus.*—On November 23 the first trial with gill nets for whitefish was made in 35 feet of water, 300 feet from the shore, at a point where it is said that an example of this species had been taken. Two nets were set, and remained down 48 hours. They were visited on three different occasions during that time, but no fish were found in them. The reason for setting nets in such shallow water for whitefish, was in compliance with a request made by the person who claimed to have caught a specimen on the above-mentioned ground in the fall of 1892. It was taken on a hook, which throws considerable doubt as to its being the true whitefish. So far as we have been able to learn no other specimen has since been seen.

On November 24 three more gill nets were set about 1½ miles from first position on the south side of Union Bay. Here also whitefish had been reported. Depth of water, 15 feet; temperature of water at bottom and at surface, 45°; bottom muddy. These nets remained in the water three days, and were visited each morning. No fish were found in them.

On November 26 three nets were set at the head of Union Bay, in 10 feet of water, close to the shore, where fish are said to be plentiful in summer; also two other nets near outlet or portage, about three-quarters of a mile farther south. In this place anglers have good fishing, and it was thought that if fish were running in any considerable numbers the nets would be likely to take samples of different species. The nets set at the head of the bay were taken up the following morning, nothing being found in them. Those set near the outlet remained down two days, and were visited each morning. The second morning one cut-throat trout and one chub were taken from them. During the time the nets were down a number of cut-throat trout, chub, and suckers had been taken on hook and line. Sounding and collecting with surface tow net had also been carried on whenever the weather permitted.

On November 27 three gill nets were set near the bottom, off the mouth of Union Bay, in 18 feet of water, bottom hard sand, where they remained two days. Nothing was found in them when taken up. It is reported that large numbers of fish pass over this ground, and it was thought that our efforts would be rewarded by a few specimens. The result of this trial indicates that at this season fish do not move in great numbers. The same nets were set in 96 feet of water about a quarter of a mile farther off shore, where the bottom temperature was 3° warmer than at last station. The nets were, as before, set near the bottom, but without result. Had whitefish or other species been traveling over this ground a few would have been captured.

A small creek that flows into the head or western part of Union Bay was next investigated. This creek is said to abound with trout in summer and with redfish in early fall. The water in the upper part of the creek flows with considerable velocity over a gravelly bottom. It is from 4 to 5 feet wide in most places, and about 7 or 8 inches deep; there are a few pools whose depth is nearly 2 feet. The creek is largely fed by seepage from the surrounding hills. At the time of our visit the weather was cold and the ground covered with snow, and in many places ice had formed. The stream empties into a marshy lagoon where it finds its way, through several smaller ones, into Union Bay.

Repeated trials with a small collecting seine at the mouth of the creek were made, but nothing was taken in it. Only one fish, thought to be a redfish, was seen, and it escaped under a fallen tree. Unsuccessful hauls were also made from a half to three-quarters of a mile upstream. Hook-and-line fishing was also tried, with the same result, salmon eggs being used for bait. At the mouth of the creek a salamander was found, and this was the only form of life seen, except the supposed redfish.

On December 11 gill nets were set in a number of places, from a half to three-quarters of a mile apart, in Squak Slough at the head of Lake Washington, in 9 and 10 feet of water. They were visited twice in 48 hours, nothing being found in them. The bottom temperature in the places where they were set was 44½°, surface 45½°. During the entire investigation the water in the slough was unusually high, and this probably had a great deal to do with the scarcity of fish here, for at such times, instead of following the main channel, fish would naturally scatter over a large area, thereby greatly lessening the chances of taking them. Troll fishing was tried, but with unsatisfactory results.

Nearly all of December 18 was spent in sounding and taking water temperatures. In the afternoon four nets were set on the north side of Meydenbauer Bay; depth, 102 feet; bottom and surface temperature, 46°. Nothing being in the nets the following morning they were taken up and set on the north side of Mercer Slough, nearly 3 miles farther down the lake. A trial for 48 hours resulted in the capture of one female cut-throat trout, the eggs of which were approaching a state of ripeness. Two other specimens subsequently taken showed the same amount of development. Several creeks on the west side of the lake were investigated but no fish were found.

*Whitefish.*—There is no satisfactory evidence of whitefish ever having been caught in Lake Washington, though several persons claim to have seen them. One person says in the fall of 1892 he caught a specimen, but no accurate description was given as to its shape or color, and Prof. O. B. Johnson and State Fish Commissioner James Crawford doubt whether it was the genuine whitefish, and believe that the whitefish planted in the lake no longer exist. The investigation strengthens this opinion. The Columbia chub (*Mylocheilus caurinus*) is a common species in the lakes of this region, and is by many people known as "whitefish." It is not improbable that all the so-called "whitefish" which have been reported from Lake Washington were really this species of minnow. Williamson's whitefish (*Coregonus williamsoni*) doubtless occurs here, but no specimens were seen.

*Other fishes of Lake Washington.*—The various species of fishes collected during these investigations, as well as all other species known to occur in Lake Washington, are listed in another part of this report. The principal species are the cut-throat trout, Columbia River chub, squawfish, Columbia River sucker, a blob, two or three other species of *Cyprinidæ*, and the redfish. Salmon are said to enter the lake through Black River early in the fall, but none was seen. They are probably the large form of the redfish or sockeye (*Oncorhynchus nerka*). Redfish are said to run up into shallow places during the latter part of October and a part of November, but repeated trials resulted in collecting only a few specimens. Those familiar with the different runs of fish on the lake attribute the scarcity of redfish this season to high water. In Squak Slough, where they are said to run in great numbers, not a specimen was seen or taken, though before the water began to rise in the slough a considerable body of these fish was reported as passing through. Black bass are occasionally

taken in Lake Washington, and they are at times quite plentiful in Lake Union, which supplies all the black bass to the Seattle market. The yellow perch (*Perca flavescens*) has also become well established in this lake.

## LAKE SAMMAMISH, WASHINGTON.

While engaged in carrying on observations upon Lake Washington Mr. Alexander made a trip, December 31 to January 6, to Lake Sammamish, a short distance to the eastward. He gives the following account of this lake and the investigations:

This body of water lies parallel to Lake Washington, the two lakes being separated by a hilly strip of country, the most narrow part being 3½ miles across. The greatest distance between the lakes is 8 miles.

Lake Sammamish is 38 feet above low-water mark at Seattle and 4 feet above Lake Washington. The land separating the southern portion of the bodies of water might be termed mountainous; many of the hills rise from 1,000 to 1,500 feet from their base, and are covered mostly with a dense growth of trees. A road cut through the forest from the west shore of Lake Sammamish to the east side of Lake Washington is traveled considerably during the summer months. A boat connecting at the end of the road carries passengers across Lake Washington and lands them in Seattle much sooner than if they traveled by rail.

The length of Lake Sammamish is 8 miles; its greatest width (about halfway between its north and south points) is 1⅔ miles. Its narrowest part is near the northern end, a little over half a mile from shore to shore. From Inglewood, in the northern part, to Monohan on the south it has a nearly uniform width of about 1½ miles. It lies nearly in a north-and-south direction; a line being drawn north from the south end would strike 1 mile east of its most northern part. The Seattle and Lake Shore Railroad strikes the lake at Adelaide, and follows the east shore the entire length. Three small towns are situated near the shore on the east side. The most important is Monohan, near the south end. On the west side a number of settlers have made considerable clearings. Opposite Monohan is a huge pile of sawdust, which extends for a considerable distance into the lake, and when the water is rough small chunks of it are washed away. It being water-soaked, most of it that falls into the lake immediately sinks. The sawdust coming from the mill at Monohan is burned.

*Topography of the shore.*—The shore in most parts of Lake Sammamish is composed chiefly of sand and gravel, forming numerous beaches. These beaches, when the water is at its normal height, are exposed. At the time of our visit to the lake (December 31 to January 6) the water was about 4 feet higher than in summer; it had then fallen 2 feet since the middle of December. Judging from the condition of the lake at high water, the beaches when exposed must be from 8 to 12 feet wide, measuring from the water's edge to the bank. In most places they extend offshore at a sharp angle. Except in a few places, where the sandy and gravelly beaches appear, the bottom makes off gradually and its character is either hard or soft mud. The southern shore of the lake is skirted by low marsh land, which extends from the southwest to the southeast side. Here several small creeks empty into the lake, which, no doubt, have contributed largely to the marsh land.

The hills bordering the southern portion of the lake descend with a more gradual slope than those on the east and west sides. The land in the immediate vicinity of the lake is not more than 4 or 5 feet higher than the level of the water, gradually

rising for a distance of about a mile before the foothills are reached. Many portions of this slope have been cleared. Off the points in this part of the lake, from 30 to 40 feet from the shore, thick clusters of tule are submerged in water from 7 to 10 feet deep. Later in the season a large portion of the ground in which this grass grows is exposed. Soundings were made along the outer edges of these strips and points without finding any indications of hard bottom.

On the east and west sides of the lake the steep hills rise within a short distance from the water; in many places projecting points and bluffs rise very abruptly, with little or no shore line at their base. The bottom close to these projections is hard, being composed of a mixture of sand, coarse gravel, and small stones. The hilly land is covered with a dense growth of trees, extending to the water's edge, and at times when the water is high it is very difficult to walk any distance along the shore without swinging from one bough of a tree to another. When the water is low or at its average height the sand and gravel beaches here are bare.

At the foot of the lake, on the northeast side near Squak Slough, a low point of land extends for a considerable distance southward. From this point south, a distance of nearly 2 miles, the shore is composed of sand and gravel beaches. On the west side and north from where the last line of soundings was begun the hills gradually descend to the shore, and in a number of places toward the foot of the lake the land is quite level. The shore line along the northwest and northeast portions of the lake is covered with logs, slabs, and pieces of timber, refuse material that comes from the shingle mill situated near the north end and the sawmill near the south end. The greater part of this material is found in the northeast portion of the lake, being forced there by the southwest winds.

On the west side of the lake, near its southern end, is a submerged forest, about half a mile long north and south, extending nearly a third of the distance across toward the east side. The northern end of the forest commences near the pile of sawdust already mentioned. It runs parallel to the shore and is separated from it by a distance of about 600 feet. During the summer months it is said that the tops of many of the trees project above the water from 1 to 2 feet. The lake then is much clearer than in winter, and on a bright day, when the water is smooth, a large portion of the forest, according to the statement of people living at the lake, is plainly visible. Owing to the muddy condition of the water, caused by the heavy rains, we were unable to find any of the trees. Many theories are advanced by people living near the lake as to how the forest came to be in its present position. The most common theory is that at some remote period a gigantic landslide occurred and the displaced material found a resting-place at the bottom of the lake. Considering that the nearest hills where a landslide of such magnitude could have started are situated nearly 2 miles from the lake with comparatively level country lying between, this theory is not altogether tenable. A large tract of land becoming detached from the side of a mountain and carried along rapidly by its own weight a distance of a mile or more from its starting point would by the time it reached its destination be a huge mass of trees, earth, and stones. The trees would be more or less broken, and not left standing in an upright position. It is also likely that if the forest in question had suddenly been detached from the side of one of the adjacent mountains it would have stopped on arriving at comparatively level ground, but instead we find it deposited a long distance from hills of any great size. If, however, such had been the case, and it was forced

along over level ground, we might expect to find that part of the lake where the landslide was deposited more shallow than elsewhere; but, on the contrary, we find a depth of water varying from 50 to 70 feet, which corresponds with depths found in other parts of the lake the same distance from the shore. It seems more reasonable to suppose that at some distant period the ground on which this forest grew, subsided. This, in a measure, would account for the trees being left standing in their natural position. Not having seen any portion of the submerged forest, we are not able to state from personal observation anything concerning it, only stating what has been given by several reliable parties. Efforts were made to locate some of the trees, but none of them could be found with the sounding line.

*Depth of water and character of bottom.*—Lake Sammamish is quite uniform in depth, varying from 70 to 90 odd feet in the middle and from 35 to 50 feet near the shore. The deepest sounding was found near the middle of the lake, about halfway across from Hattie Bell Springs to the west shore. A line of soundings run across the upper part a short distance below the shingle mill corresponds nearly with the line across the south end of the lake. In no part of the lake examined are there indications of plateaus or shelves making off from the shore. Only in a few places was shallow water found, and this extended but a short distance from the shore. In nearly all parts of the lake along its margin the bottom drops off suddenly, the water being deep enough for boats and small steamers to lie alongside and discharge freight or passengers.

From 80 to 100 feet from the shore is the average distance where the sand and gravel merge into the hard or soft mud. A number of places, however, were found where sand and gravel bottom extends from 125 to 300 feet into the lake; one of these places is on the west side, opposite Hattie Bell Springs, and the other off the wharf on which the sawmill at Monohan is built.

At the foot of the lake, above the shingle mill, the bottom is very soft and in the center between the east and west sides the mud is said to be several feet deep, and this statement is probably not exaggerated, for in running the line of soundings which ends just below the shingle mill the sounding lead, nearly all the way across, sank into the soft bottom a foot or more.

*Inlets.*—Numerous small creeks empty into the lake both on the east and west sides, but the discharge of water is not great even during the rainy season, and in summer many of them dry up, they being fed by the drainage from the surrounding hills. The principal inlets are Issaquah and Manner creeks, which enter the lake on the south end. The main portion of the first creek is 2 miles long and the second about 3 miles, each having several branches from ½ to 2½ miles long. The water in Issaquah Creek is said to be very clear during the summer and fall months, or was previous to the coal company using the creek as a dumping-ground for coal screenings, since which time the water has become muddy. There are a number of coal mines in this region, and the people complain of the screenings from them being dumped into the creeks, thereby doing considerable injury to the fishing-grounds.

*Outlet.*—Squak Slough, or Sammamish River, is the only outlet to the lake. This at times is not large enough to prevent the water in the lake from rising rapidly, and when Lake Washington rises at the same time, which is usually the case, and forces the water from the slough into Lake Sammamish, both lakes rise rapidly. At the

time of visiting Lake Sammamish the water had overflown the channel of the slough from a quarter to a half mile; its average width for the part visited is less than 100 feet, in some places not over 50 feet. Its length is about 12 miles; its course, as indicated on the map, is very crooked, and it is navigable for small craft only.

*Temperatures.*—The water temperatures during our investigation varied but little, and in many parts of the lake there is no difference. In the first line of soundings run across the lake the surface and bottom temperatures were the same. The weather at the time was rainy, misty, and cold. In the second line a difference of 1° was found in two places, each in a depth of 90 feet. At the surface the thermometer registered 45° and at the bottom 44°. In the third line the depths were from 33 to 92 feet, with no variation in temperature. The fourth line, run the same day, shows in eight different soundings 45° at the surface and 44½° at the bottom. The fifth line, run across the head of the lake, showed no difference; but in a number of soundings taken on the west side, near where a small brook empties into the lake, the water was 1° warmer at the surface than at the bottom. The depths here were comparatively shallow. The last line of soundings run, which was across the foot of the lake, also showed the water to be 1° warmer at the surface than at the bottom. This difference may possibly have been because the weather was warm and pleasant, while most of the time, when the other soundings were taken, it was rainy and foggy and the temperature of the air from 44° to 50°. On this day, January 6, it registered 60° a greater part of the day.

Where the water at the surface was warmer than at the bottom it was found that the warm water extended from 5 to 8 feet below the surface; where the temperature at the bottom was warmer than at the surface the water was constant from 15 to 18 feet from the bottom. The thermometer was let down at various depths, in most cases at intervals of 10 feet, no variation in temperature being noticed until the above distance from the bottom was reached. In a few places, however, within 10 feet of the bottom the water remained constant.

*Condition of water.*—In the fall and winter, when the lake is high, the water is considerably discolored by vegetable matter and sediment washed from the surrounding hills and brought down by the swollen creeks. This gradually disappears as the rain ceases, after which the water becomes clear. The fish then bite better than at any other time, there being less food in the water for them to subsist upon.

Lake Sammamish, like Lake Washington, never freezes over. When the weather is unusually severe skim ice sometimes forms near the edge in shallow places, but the deep water does not freeze.

*Fishing trials.*—From December 31 to January 6 sounding, taking temperatures, collecting with surface tow net, and fishing with gill nets and troll were carried on. The weather most of the time was stormy. Fishing with gill nets was unsuccessful. They were set in various places and in different depths, visited twice each day, and in the evening set in a different place. Inquiries were made of fishermen as to where fish would most likely be found, but nothing was caught. A trawl was the only stationary apparatus used that captured anything, and this caught only one chub and a blob.

Fishing with troll line was fairly successful, five cut-throat trout being taken. The weather was unsuitable for this kind of fishing. To meet with good results the weather should be moderate and much warmer than it was during the time these trials

were made. Fishermen say that in summer, and at other times when the weather is pleasant, it is comparatively easy to catch from twenty-five to thirty trout in a day by trolling.

Trout would bite only when the wind was light and the lake smooth. During the day, whenever there was little wind stirring, they could be seen jumping or breaking water in all parts of the lake, but they did not bite as ravenously as was expected, probably on account of the creeks having brought down considerable quantities of vegetable and other matter, such as they may feed upon. Fishermen claim that the fish never bite well when the lake is high. Several good examples, however, were caught in the few trials made. When fish are at all inclined to bite, a trawl will usually pick up a variety of species. The trawl set (90-odd hooks) was baited with fresh chub and meat, and good results were expected of it, but in this we were disappointed.

The trout taken by trolling were caught close to the shore, that being the part of the lake where the fishermen troll when the water is high. Fish were breaking water in the middle of the lake, but none was captured. In summer good fishing is to be had in all parts.

*Methods of fishing.*—The principal method of taking fish in Lake Sammamish is by trolling, though good catches are sometimes made with set line and with rod and line. In summer the lake is quite a resort for sportsmen from Seattle. No commercial fishing is carried on, all fish caught being locally consumed, except the few taken to Seattle by people belonging there.

*Kinds of fish.*—The economic species of fish found in Lake Sammamish are the same as those of Lake Washington, namely, cut-throat trout, "grayling," or redfish, and salmon. No examples of the last two species were found, they having disappeared shortly after the water in the lake began to rise in November. About that time it is said that redfish were plentiful in Squak Slough and in the creeks at the head of the lake. Salmon run with the redfish, but only scattering individuals are taken. No information could be obtained as to what kind of salmon enter the lake; but the dog salmon and an occasional steelhead probably find their way into this body of water. During the redfish run the neighboring Indians do considerable fishing on Squak Slough, and lay in their supply for winter. Only one person living near the lake claims to have caught a whitefish in it, and he was not sure that the specimen was a genuine whitefish; others who saw the fish say that it was not, but admit that the fish differed from any previously taken in the lake.

*Spawning habits.*—People living near Lake Sammamish say that the cut-throat trout spawn in the spring and the condition of most of the specimens indicates that they are correct in their observations. One taken in Lake Washington contained eggs well advanced, but this fish would hardly indicate a difference in the spawning season between the two lakes, as fish can easily pass from one lake to the other. The redfish probably spawn some time in November, that being the time they run in greatest numbers. Only a few specimens were taken, and they were not sufficiently developed to form an estimate as to the month in which they spawn, but people who have caught and observed the redfish, both in Lake Sammamish and Lake Washington, believe that the spawning season is from the latter part of October to the middle of November. To gain a better knowledge as to the habits of this species in this region some person should be stationed at these lakes early in the fall, before the rainy season comes on.

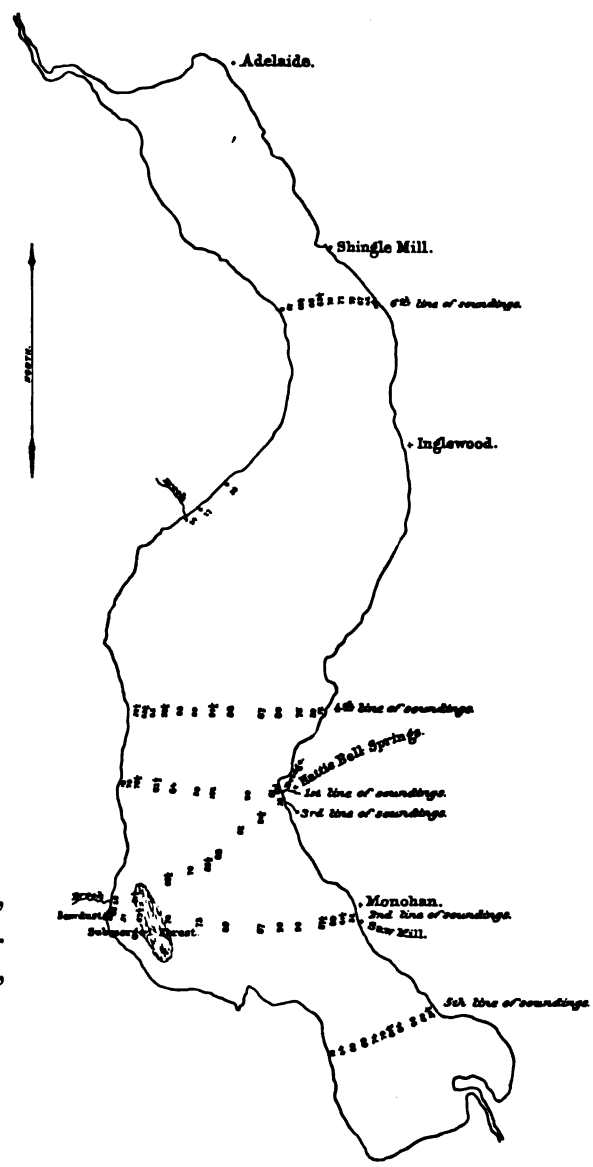
It is said that redfish run only for a short time, that they disappear as suddenly as they come, and few are seen in any part of the lakes after the run is over. Almost every person with whom we conversed on the subject expressed the opinion that the redfish, or "grayling," as they are commonly called, annually come in from the ocean; but some believe that they never leave the lake, but retire into the deep parts of the lake as soon as the spawning season is over. Positive knowledge on the subject is lacking. The few specimens taken in Lake Washington would hardly warrant an opinion to be formed as to their habits in these lakes. It would be necessary to observe a considerable number from the time they first appear until they leave.

*Surface material.*—Collecting with surface tow net was carried on at different intervals. As was the case on Lake Washington, surface life was found most abundant in the evening; at other times a trial of 15 or 20 minutes would result in a small quantity of material.

*Depth of water, temperature, and character of bottom of Lake Sammamish.*

| Date. | Depth of water. | Character of bottom. | Temperature of surface. | Temperature of bottom. | Date. | Depth of water. | Character of bottom. | Temperature of surface. | Temperature of bottom. |
|---|---|---|---|---|---|---|---|---|---|
| 1896. | *Feet.* | | °F. | °F. | 1897. | *Feet.* | | °F. | °F. |
| Dec. 31 | *a* 19½ | Hard sand.... | 45 | 45 | Jan. 2 | 85 | Soft mud..... | 45 | 44½ |
| 31 | 61 | Hard mud.... | 45 | 45 | 2 | 93½ | .....do..... | 45 | 44½ |
| 31 | 90 | Soft mud..... | 45 | 45 | 2 | 93 | .....do..... | 45 | 44½ |
| 31 | 102 | .....do..... | 45 | 45 | 2 | 90 | .....do..... | 45 | 44½ |
| 31 | 90 | .....do..... | 45 | 45 | 2 | 99½ | .....do..... | 45 | 44½ |
| 31 | 84 | .....do..... | 45 | 45 | 2 | 88 | .....do..... | 45 | 44½ |
| 31 | 82½ | .....do..... | 45 | 45 | 2 | 87 | .....do..... | 45 | 44½ |
| 31 | 76½ | .....do..... | 45 | 45 | 2 | 80 | .....do..... | 45 | 45 |
| 31 | 90 | Hard mud, sand..... | 45 | 45 | 2 | 75 | .....do..... | 45 | 45 |
| 31 | 13 | Gravel..... | 45 | 45 | 2 | 30 | .....do..... | 45 | 45 |
| 1897. | | | | | 2 | 12 | .....do..... | 45 | 45 |
| Jan. 1 | *b* 32 | Sand..... | 45 | 45 | 2 | 19 | .....do..... | 45 | 45 |
| 1 | 61½ | Soft mud..... | 45 | 45 | 2 | 44 | Hard sand.... | 45 | 45 |
| 1 | 80 | .....do..... | 45 | 45 | 2 | 60 | Soft mud..... | 45 | 45 |
| 1 | 87½ | .....do..... | 45 | 45 | 2 | 69 | .....do..... | 45 | 45 |
| 1 | 90 | .....do..... | 45 | 44 | 2 | 74 | .....do..... | 45 | 45 |
| 1 | 90 | .....do..... | 45 | 44 | 2 | 79 | .....do..... | 45 | 45 |
| 1 | 87 | .....do..... | 45 | 45 | 2 | 81½ | .....do..... | 45 | 45 |
| 1 | 80 | .....do..... | 45 | 45 | 2 | 84 | .....do..... | 45 | 45 |
| 1 | 73 | .....do..... | 45 | 45 | 2 | 66 | .....do..... | 45 | 45 |
| 1 | 70 | .....do..... | 45 | 45 | 2 | 50 | .....do..... | 45 | 45 |
| 1 | 69½ | .....do..... | 45 | 45 | 6 | *e* 5 | Hard gravel... | 46 | 45 |
| 1 | 51 | .....do..... | 45 | 45 | 6 | 24 | .....do..... | 46 | 45 |
| 1 | 36 | Sand and gravel..... | 45 | 45 | 6 | 6 | .....do..... | 46 | 45 |
| 1 | 28 | .....do..... | 45 | 45 | 6 | 27 | .....do..... | 46 | 45 |
| 2 | *c* 61½ | Soft mud..... | 45 | 45 | 6 | 30 | .....do..... | 45 | 45 |
| 2 | 66½ | .....do..... | 45 | 45 | 6 | *f* 6 | .....do..... | 46 | 45 |
| 2 | 70 | .....do..... | 45 | 45 | 6 | 57 | Soft mud..... | 46 | 45 |
| 2 | 85½ | .....do..... | 45 | 45 | 6 | 62½ | .....do..... | 46 | 45 |
| 2 | 88 | .....do..... | 45 | 45 | 6 | 68 | .....do..... | 46 | 45 |
| 2 | 92 | .....do..... | 45 | 45 | 6 | 69½ | .....do..... | 46 | 45 |
| 2 | 91½ | .....do..... | 45 | 45 | 6 | 70 | .....do..... | 46 | 45 |
| 2 | 33 | Hard sand.... | 45 | 45 | 6 | 72 | .....do..... | 46 | 45 |
| 2 | *d* 32½ | Hard sand and gravel..... | 45 | 45 | 6 | 70 | .....do..... | 46 | 45 |
| 2 | 83½ | Soft mud..... | 45 | 44½ | 6 | 67½ | .....do..... | 46 | 45 |
| | | | | | 6 | 42 | .....do..... | 46 | 45½ |
| | | | | | 6 | 10½ | Coarse gravel. | 46 | 46 |

*a* About 20 feet from bridge; first line sounding.
*b* Second line of soundings 250 feet from sawmill.
*c* Commencement of third line of soundings.
*d* Commencement of fourth line of soundings.
*e* Soundings close to a brook.
*f* Sixth line of soundings 20 feet from shore.




Lake Sammamish, near Seattle, Wash., showing soundings taken by U. S. Fish Commission, in December, 1896, and January, 1897.

## LAKE UNION, WASHINGTON,

The following notes on Lake Union have been furnished by Mr. Alexander:

This body of water lies close to the city of Seattle. Its length, measured in a straight line from north to south, is 1½ miles; width, halfway between the north and south ends, three-quarters of a mile. Branching out from the head of the lake are two arms, one leading to the northeast and the other to the northwest. Measured from the foot of the northeast arm the lake has a length of 3¼ miles.

Lake Union has a quite uniform depth in the center; the greatest depth, 48 feet, is found in nearly all parts of the main body a quarter of a mile from the shore. In the northeast arm the soundings varied from 24 to 27 feet. Near the shore, except in places where there is marsh land, the depth is from 18 to 25 feet. In the south end of the northeast arm the land is marshy; also off the point extending into the northern part of the lake between the two arms. In most other parts grass land extends down to the water's edge with a gradual slope. On the east side the land is quite level and covered with willow and other trees. This strip of land extends back from the lake for a considerable distance, when it suddenly runs into high bluffs.

The land surrounding the lake for the most part is high and was at one time heavily wooded, but now only small clumps of trees are left standing, most of the once great forest having given way to town sites and buildings. Skirting the north shore runs the Seattle and Lake Shore Railroad. The shore is thickly settled, except on the east and northeast sides.

The bottom in nearly all parts is mud, in some places intermingled with fine sand.

From the 2d to the 8th of December gill nets were set in ten different places, taking 4 salmon, 1 cut-throat trout, and 2 suckers. In no place were the nets down less than 24 hours, and in one place they remained down 72 hours. They were set in places best adapted for this kind of fishing and where black bass had been caught in greatest numbers. Trolling for black bass was carried on at different times, but nothing was caught. The season was too late for them, but it was thought that the gill nets might capture a specimen or two.

During the summer black bass are frequently taken by trolling, and it is reported that they are sometimes taken in nets secretly set for their capture. This method is illegal, but is carried on to some extent. Only a few black bass have been caught in Lake Washington, and those planted in this lake in 1890 soon found their way into Lake Union, where they are said to be quite plentiful during the summer months. Why they should find the water in Lake Union better suited to their wants than where they were planted is not easily explained. It can not be due wholly to the difference in the condition of the water, for Lake Washington largely supplies Lake Union. The theory that presents itself to account for these fish being found in Lake Union and not in Lake Washington is that in the former lake small surface life is much more abundant. The collections made in the two lakes show a considerable difference in the amount taken in each trial.

In winter the temperature of water of this lake is several degrees colder than that of Lake Washington, though ice seldom forms, and only when the winter is unusually severe does the lake freeze over; it is probable that in summer Lake Union is the warmer, it being shallow.

*Temperatures taken in Lake Union.*

| Date. | Time. | Depth. | Temperature. | | Date. | Time. | Depth. | Temperature. | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Surface | Bottom | | | | Surface. | Bottom. |
| 1896. | | *Feet.* | °F. | °F. | 1896. | | *Feet.* | °F. | °F |
| Dec. 2... | 9.00 a. m ..... | 6 | 42 | 44 | Dec. 2.... | 4.20 p. m ..... | 24 | 43 | 42 |
| 2... | 11.00 a. m ..... | 21 | 42 | 44 | 2.... | 4.45 p. m ..... | 27 | 42 | 43 |
| 2... | 3.20 p. m ..... | 12 | 42 | 42 | 3.... | 10.30 a. m ..... | 48 | 43 | 42 |
| 2... | 3.30 p. m ..... | 48 | 43 | 42 | 3.... | 12.15 p. m ..... | 48 | 43 | 42 |
| 2... | 3.40 p. m ..... | 36 | 43 | 42 | 3.... | 1.00 p. m ..... | 9 | 41 | 42 |
| 2... | 4.00 p. m ..... | 24 | 43 | 42 | | | | | |

## SIUSLAW RIVER, OREGON.

In 1894 the State of Oregon erected a building on the Siuslaw River at Mapleton, Oregon, with the intention of conducting salmon-cultural operations at that place. This building finally reverted to the original owner of the land upon which it was located. Believing that this station could be successfully and profitably operated, the owner, through Mr. L. E. Bean, of Mapleton, kindly offered its free use to the United States Fish Commission for that purpose. In response to this offer Dr. Meek and Mr. Alexander were instructed to visit the station and make such examination as would determine the probability of its being operated advantageously. The preliminary inquiry, made early in September, showed that it would be necessary to catch the fish at the fishing-ground, several miles below the station, and retain them in boxes until ripe. It was thought that this could be done and that the boxes could be floated on the tide up to the station. This could be determined only through experimentation. Dr. Meek was therefore instructed to return to Mapleton and thoroughly test the matter.

*General description of Siuslaw River.*—The Siuslaw River is one of the short coastal streams in Oregon whose basin is confined entirely to the western slope of the Coast Range. From its mouth to its source is a distance of about 100 miles. It drains a very broken country, which is quite heavily timbered. From the mouth of Wildcat Creek to near the mouth of North Fork the river flows through a canyon ½ to 3 miles in width. The hills or mountains on each side of the canyon are from 200 to over 1,000 feet above the river and are very steep. At the mouth of North Fork is a large area which is covered by water only at high tide. This region, known as the mud flats, is on the north side of the river and includes most of the distance between Acme and Florence. At Florence the river turns nearly north and then curves slightly toward the west. The right-hand bank is, for the most part, a low bluff of soft sandstone; the left is bordered by sand hills.

The Siuslaw River above the mouth of Wildcat Creek was not visited, but from what we were able to learn that portion is quite similar in all respects to the part immediately below that creek, except that gravel bars become much more frequent as you ascend the river. From the mouth of Wildcat Creek to the head of tide, a distance of about 24 miles, the bottom of the river is sandstone *in situ*, over which, in many places, are scattered large, angular, somewhat water-worn, sandstone bowlders. The river above head of tide water is from 60 to 200 feet in width, and during the summer in many places the water is less than 2 feet in depth.

The canyon is cut through sandstone, which in some places is nearly horizontal, while in others it is tilted more or less, seldom more than 30°. The only portion noticed which showed signs of being metamorphic is a bluff on the right hand of the river between Seaton and Mapleton.

The timber in the region drained by the Siuslaw is chiefly fir, some cedar, hemlock, spruce, maple, and alder. Some of the alders are as much as 18 inches in diameter, and some of the fir trees a short distance west of the summit of the Coast Range are very high. There is also in this region a very rich growth of ferns, chiefly the common *Pteris*. A large portion of the timber along the lower 30 miles of the Siuslaw was destroyed by fire some sixty years ago. This is being replaced by an undergrowth of fir, alder, maple, etc. The timber bordering the sand hills is mostly bull pine.

The North Fork of Siuslaw River is much smaller than the main river. In the neighborhood of Minerva the deeper holes in the river are from 20 to 50 feet wide, the shallow places connecting these holes being about half this width. Along the river, for a distance above tide water of about 8 miles, are many gravel bars over which the water flows during the summer in depths varying from a few inches to about 3 feet. The timber along the North Fork is similar to that on the main river, the under or smaller growth immediately on the banks being some denser. Very little timber along the North Fork below Minerva has been destroyed and scarcely none above that place. The water in North Fork is clear, though considerably stained by vegetation, much more so than in the main fork.

The water in the Siuslaw in the summer is moderately clear, though slightly discolored by vegetation. It also contains a fine silt or sediment of some sort, which collects on the web of gill nets. At flood tide, about halfway between Florence and Mapleton, the water appears of a reddish color, apparently due to the mingling of the comparatively fresh with the brackish water, the salt in the brackish water precipitating the clay sediment in the fresher water. During the summer, at the head of navigation, the water at all times is too brackish for steamboat boiler use.

The head of tide water is about half a mile above Seaton. About half a mile below Seaton is an island in the river, on either side of which, at low tide, the water in the deepest place is less than 3 feet. Small steamers drawing about 3½ feet of water can not pass this island in summer except at from half to full tide.

Mapleton is 1 mile below Seaton. Below Mapleton in summer and at low tide the water in the shallow portions of the river is seldom less than 10 or 12 feet in depth. Seaton is properly the head of tide water, Mapleton the head of navigation.

The river below Mapleton will average at least twice as wide as it does above it, and it varies in depth at low tide in summer from 10 to 12 feet to as much as 60 feet.

On October 16 a series of bottom temperatures from Martin Creek to Acme was taken. The temperature of the air at 8 a. m. was 57°; surface of the water at Martin Creek, 57°; bottom at same place at a depth of 15 feet, 58°. This bottom temperature decreased as we approached the lower portion of the river until at Acme, in 30 feet of water, it was 54°.

*The fishermen, methods of fishing, etc.*—The fishermen on the Siuslaw River are with few exceptions Americans, Norwegians, and Indians. The fishing on the main river is done for the most part by the Americans and Norwegians, on the North Fork mostly by Indians. During the past season about three-fourths of the fishermen were permanent residents on the river; the remaining one-fourth were mostly from the Columbia River, and in general they restricted their fishing to the lower 8 miles of the river, using drift nets. The resident fishermen are further up the river and set their nets in the ordinary way. Each fisherman regards himself as privileged to fish anywhere along the river he chooses. The fact that a man owns property on the river

is apparently no reason why he should restrict his fishery to his own water front or prevent anyone else from fishing there. For convenience each resident sets his nets as near his home as possible and has usually a number of well-defined sets; which are sometimes marked. These sets are the places which he regards as the best in which to catch fish, and are free from snags. One fisherman will seldom intentionally use a set belonging to another.

During the past year very little attention was given to the "Saturday night law." It was said that this has not only been the case in past years on the Siuslaw River, but that it is practically a dead letter on all of the streams in Oregon. The fishermen on the Siuslaw seem to agree that all of them would profit as well by respecting it as by breaking it. A few persist in setting their nets or drifting Saturday nights and, in order that these few men may have no advantage over the others, they, too, put out their nets on Saturday nights.

According to the law the fishing season closes on the Siuslaw River November 1. This law, of course, is intended for all of the coastal streams in Oregon, and as the time of the run of salmon, especially of silver salmon, varies somewhat in the different rivers the law does not protect all alike. In the Siuslaw River the largest run of silver salmon occurs anywhere from October 25 to November 10. About this time the first fall rains begin and a gradual rise in the river is accompanied by an increased run of silver salmon. In 1896 the rains began October 24. The river did not rise much until the night of November 7, when it rose about 8 feet, which put an end to fishing.

The largest run of silver salmon was between October 28 and November 6. About the same condition of affairs is said to have existed last season.

The law which requires the season to close November 1 in no way protects the chinook salmon, as the run of this fish is over by October 15. As fishing is the chief source of income of many of the citizens on the Siuslaw River it seems to them quite a hardship to be obliged to stop fishing during the best portion of the season. All commercial fishing on the river is confined to that portion below tide water; in fact very little is ever done above Mapleton until near the close of the fishing season. The distance from the head of tide to the mouth of the river is about 28 miles.

Commercial fishing on the Siuslaw is carried on by gill nets, seines, and trolling lines, but mostly by gill nets. The gill nets operated by the fishermen engaged in drifting are from 100 to 150 fathoms long; they are used only on the lower 8 miles of the river, where the current is too swift during flood and ebb tides to allow them to be set in the ordinary way. There are a great many sunken logs and trees in this portion of the river, as well as further up the stream, and the drifts are therefore usually short. All gill nets used on the river from the head of tide water to within 8 miles of its mouth are set in the ordinary way. They are all anchored by heavy rocks tied to the lead line at distances of from 3 to 8 fathoms apart. They vary in length from about 25 to 100 fathoms.

That portion of the river in which gill nets are set varies from about 8 to 150 fathoms in width. The gill nets also vary in length and, as no fisherman confines his fishing to any one portion of the river, very little attention is paid to the law which prohibits the use of gill nets reaching more than one-third distance across the river. Nets set in the Siuslaw River reach all the way from one-fourth to the entire distance across it. During flood and ebb tide the current in the river is so swift that nets extending from about one-third to two-thirds across the river have their cork line dragged so low that the net presents a comparatively small and a very poor fishing

surface. If the net extends from bank to bank the current raises the lead line between anchor rocks and drags down the cork line to the extent of destroying a good share of the fishing capacity of the net. It is quite evident that nets set in the Siuslaw River fish very little except during slack water.

During the new and full moon tides the current in the river is so swift that the outer ends of the nets, which reach only a part way across the river, are drifted toward the shore, and they frequently become so much snagged in drifting one way that it is impossible to pick them up until the return tide. The fishermen drifting always take advantage of slack water, in order to fish their nets a longer time without taking them up. In the latter part of the fishing season many nets used in drifting are cut into shorter lengths and set farther up the river. It seems to be a fact recognized by the fishermen that in any one portion of the river a net will fish much better at one bank than at the other, so it is much more advantageous to have two nets, each reaching halfway across the river, than one single net reaching entirely across. Three nets each reaching one-third distance across the river are often preferable to a single net reaching the entire distance. Nets are seldom set in the river in the daytime.

Gill nets are also used in surf fishing late in the fishing season, when comparatively few salmon are entering the river. The usual depth of the net used in surf fishing is about half that used in drifting. At either end of the nets, which are about 150 fathoms long, long ropes are attached. The net is stretched along the shore and allowed to be caught by the surf, which carries it some distance to sea; it is then slowly drawn to shore after the manner of a seine. This method of fishing is so difficult and the results so small that it is not much followed.

A short distance above Acme is an excellent seining-ground, but the use of a seine has usually been opposed by fishermen using gill nets farther up the river. The seine was used this season from September 10 to November 1 by those who most strongly opposed it last year, but was less profitable than was expected. The majority of the fishermen would favor a law restricting the fishing to the use of gill nets. The seine was but little disturbed this year. One night a boat filled with rocks was sunk on the ground, but this the seine brought ashore at its first haul next morning. At another time a peculiar framework was anchored in the river, which was so constructed as to raise the lead line when the seine was about half hauled in. This contrivance was also brought ashore. The fact that the seine did not meet with the success expected lessened the opposition to its use. Chinooks were caught by it for the hatchery, and this was no doubt a factor in its favor.

Chinooks and the silver salmon are often caught by trolling in the Siuslaw River, and they occasionally take hooks baited with salmon eggs or other bait. On October 10 Mr. L. E. Bean caught 3 chinooks and 6 silver salmon trolling for about an hour near the mouth of Martin Creek. The following day 8 silver salmon were caught by trolling from Mapleton to Point Terrace, a distance of about 6 miles. Some of the chinooks and silver salmon caught in this way were red in color and the jaws distorted. Considerable trolling is done during October between Mapleton and Point Terrace, not only for sport, but for market as well. The amount of fishing done on the Siuslaw River is rated by boats, each boat having ordinarily 2 men and about 100 fathoms of net. This past year there were from 75 to 80 boats engaged in fishing on both the Siuslaw River and North Fork, using a total of about 10,000 fathoms of net. The seine was operated by 6 men and 1 horse, and was equivalent to 3 or 4 boats.

The legal fishing season extends from September 1 to November 1. Some of the fishermen begin fishing as soon as the law permits, but the majority do not commence until the cannery begins operations. Tests made in August and early in September showed that the chinook salmon did not arrive in considerable numbers until about the 10th of September. They began to enter the river in the early part of August. Very few were caught in the lower part of the river after the middle of October. In the vicinity of Mapleton, however, a good many were taken as late as the last of October. They moved up the river apparently very slowly, evidently remaining for a considerable time in the deeper portions of the river.

At Point Terrace the water is 56 feet deep; near the mouth of Martin Creek the water is from 25 to 36 feet in depth. A large number of chinooks remain in these places (or are thought to, at least) until they become red and distorted. They seem to be very inactive. Gill nets set near these places catch very few. Fishermen say that as soon as the first fall rains come and the water in the river freshens up a little the fish become very active and are easily caught in large numbers. No special effort is ever made to catch the chinooks from Point Terrace to head of tide after about the 10th of October. Many of those taken after this date are so white-meated that they are worth not over 5 cents each, and they are usually thrown overboard by the fishermen. Some fishermen think that many chinooks spawn on the margins of these deeper holes, but there is no positive evidence of this further than that late in the fishing season a few ripe females are caught near or in these deep holes.

October 28 and 29, just after the first important fall rains, about 50 chinooks were caught near Mapleton, which was the largest catch at this place during the season. A few of these were ripe and others nearly so. These fish were evidently just leaving the deep hole near the mouth of Martin Creek about three-quarters of a mile below Mapleton. The larger portion of this catch was rejected by the cannery.

The fall rains not only increase the amount of water in the river and freshen the lower portion of the stream, but they also lower the temperature of the water. These are doubtless the main factors causing the salmon to leave the deep holes and resume their run upstream.

Salmon ordinarily reach their spawning-grounds before they are ripe, but there is considerable evidence that they sometimes do not enter the river until almost ripe. Mr. Leonard Christianson did considerable surf fishing in November, 1895, and informed us that he caught a few ripe chinooks then. Eggs were forced from them while the fish were dying on the shore. This, however, is probably unusual.

The North Fork being a much smaller stream than the main river and comparatively few white men fishing on it, it seemed that it was of very little importance as a fishing stream. Late in October it was learned that many chinooks were spawning all along the stream above tide water. On October 23 and 24 the North Fork was examined for some distance both above and below Minerva. The water was so stained that salmon could be seen only in shallow water on the gravel bars. These when frightened by our approach at once disappeared in deep water. A few were much mutilated and in a dying condition; in fact, all seen were more or less mutilated. North Fork, though not a large stream, has from tide water to a distance of about 8 miles above a number of excellent spawning-beds, and all showed much evidence of having been so used this year. On the 26th of October about 17 chinooks were caught, all spent fish and all more or less mutilated. As these spawning-beds are only about 8 to 16

miles from the sea, the mutilations exhibited could not have been incurred while on their way from the sea, but were received on the spawning-beds. Several dead ones were seen, and many others were so weak and injured that recovery was not believed possible.

On October 23 and 24 at least 50 chinooks were seen on spawning-beds. On all of these the fins were considerably frayed, while most of them were badly mutilated and covered with fungus. A few were so far gone that we captured them by wading in the water and catching them by the tails.

The seals collect in large numbers during the salmon run on the bar at the mouth of Siuslaw River. Some enter the river and are seen nearly half way to Mapleton. They are regarded as being destructive to the fishing interests, both by destroying large numbers of fishes and preventing many more from entering the river. These seals are regarded by the fishermen as by far the worst enemy of the salmon.

The run of silver salmon began later. The first examples were taken about September 10, but they did not appear in any considerable numbers until about a week later. From that date they continued pretty evenly until the 20th of October, after which they appeared in much larger numbers. They were still abundant on November 7, when a sudden rise in the river washed away many of the nets and practically put a stop to all fishing for the season.

The importance of the salmon fishery of the Siuslaw River for each year since its beginning in 1889 is shown in the table which follows. For convenience of reference the salmon taken in Tsiltcoos (Ten-mile) Creek are included.

| Year. | Siuslaw River. | | North Fork. | | Tsiltcoos Creek—silver. |
|---|---|---|---|---|---|
| | Chinook. | Silver. | Chinook. | Silver. | |
| 1889 | 9,000 | 62,340 | 4,000 | 16,432 | 8,000 |
| 1890 | 6,500 | 41,320 | 2,340 | 9,320 | (a) |
| 1891 | 16,500 | 23,450 | 6,800 | 2,100 | (a) |
| 1892 | 7,000 | 86,340 | 3,050 | 13,460 | (a) |
| 1893 | 4,000 | 78,430 | 1,100 | 12,000 | 5,300 |
| 1894 | 1,300 | 84,642 | 1,234 | 6,742 | 4,870 |
| 1895 | 4,200 | 69,454 | 1,600 | 4,340 | 8,200 |
| 1896 | 4,378 | 57,000 | 2,100 | 4,650 | 1,578 |
| Totals | 52,878 | 502,973 | 22,224 | 69,044 | 27,948 |

a Did not fish.

From this it appears that the total number of chinook salmon from the Siuslaw River and the North Fork handled by the canneries in the eight years was 75,102 fish, or 1,301,632 pounds. Mr. Kyle estimates that this amount should be increased by one-sixth, to cover the number salted or shipped away. This would give 87,619 fish, or 1,518,750 pounds. The total number of silver salmon handled during the same period was 599,965 fish, or 5,429,675 pounds; increased by one-sixth for fish salted or otherwise utilized, the total becomes 699,959 fish, or 6,334,620 pounds. The number of silver salmon taken in the outlet of Tahkenitch Lake (Five-mile Creek) is said to have averaged about 5,000 fish per year for the last three years.

*Condition of salmon.*—The chinooks caught in the Siuslaw River are not so fat as those caught in the Columbia. This is no doubt due to the fact that the Siuslaw has only a fall run. In any river the spring run is always better than the fall run; the

early spring run is better than the late spring run, and the early fall better than the late fall run. The condition of the salmon depends on the length of time he remains in fresh water before spawning. Those whose sexual organs are the least developed have redder and fatter flesh, and these are the ones which must remain in fresh water the longest time before spawning.

*Salmon taking the hook.*—Fishermen hold different opinions as to why salmon take the hook, some regarding it simply as due to the pugnacious disposition of the fish, others as showing a playful disposition. Both males and females will take the hook. The baited hook falling near them or the silvery spoon passing rapidly by no doubt produces an involuntary impulse on the part of the fish to seize it.

*The Siuslaw hatchery.*—This hatchery is at Mapleton, Oregon, on the Siuslaw River, about 26 miles above its mouth, or 1½ miles below the head of tide water. The building is about 300 feet from the river and is supplied with water by gravity from a small spring brook, which flows within 200 feet of the building. This supply is abundant and of good quality. As there was no rack in the river, fish for spawning purposes could be obtained only at the seining-ground near Acme, about 16 miles below Mapleton. The method followed was to retain the fish in live-boxes until they were ready to spawn. Special boxes were built for this purpose, the fish put in them at the seining-ground, then they were floated on the tide up to Mapleton, where they were tied until the fish were utilized.

The first live-box was built September 17. It was made 20 feet long, 10 feet wide, and 4½ feet deep. The frame-work was made of 3 by 6 material; to this were nailed horizontally 1 by 4 strips, with interspaces of about 2½ inches. The lumber used was undressed. This box will hereafter be referred to as Box No. 1. On September 19 Box No. 2 was built, 16 by 8 by 4½ feet. This box differed from No. 1 only in being made out of boards 6 and 8 inches wide instead of 4 inches, and in having the interspaces narrower. These were not more than 2 inches wide anywhere, and near the top of the sides no interspaces were left, the first two or three being placed against each other. On September 21 Box No. 3 was built, not differing in any way from Box No. 2. On the 1st of October Box No. 4 was built. It was made of dressed lumber and was 20 by 6½ by 4½ feet. Care was taken to have this box as smooth inside as possible, so that the fish might not become injured in any way on account of contact with the box.

The account of the experiments with each of these boxes is given with considerable detail, in order that the nature of the work and the conditions under which it was done may be fully understood. On September 18, 43 chinook salmon were placed in Box No. 1. They were obtained from the seines and carried in sacks a few feet to a small live-box, in which they were floated to No. 1. The next day 48 more salmon were placed in this box. On September 21, 47 salmon were placed in No. 2, and the next day 22 fish were put into No. 3, to which 6 more were added on the morning of the 23d. These three boxes, with 91, 47, and 28 fish, respectively, were lashed together and were started drifting up the river with the tide. This tide carried them upstream about 7¾ miles, or about ¼ mile below McLeod's wharf. Here the boxes were taken in tow by the steamer *Lillian* and brought to McLeod's wharf. The next day they were drifted to Point Terrace, a distance of about 5¼ miles, and on the following night they were drifted 2½ miles farther to Hartley's wharf. The next day, the 25th, they were drifted 1¾ miles farther, which brought them within ¾ mile of Mapleton. They were

tied up here until the 27th, when the *Lillian* took them in tow and brought them to the Mapleton wharf, where they were kept until the fish were spawned.

Three fish were placed in Box No. 4 on the evening of October 1, and 29 more were added the next morning. This box was set drifting on the evening of October 2. The fish were quite restless, jumping and striking against the top of the box in efforts to get out. After floating about 1½ miles this box was tied up for the night. That evening it was covered with spruce boughs, so as to darken it and at the same time to cause it to float lower in the water. The next morning it was drifted to within half a mile of McLeod's wharf, or about 6 miles. The box was anchored here until the evening flood tide, when it was drifted to McLeod's wharf and tied up. The next day it was drifted about 6½ miles to Hartley's wharf, and on the day following it was floated to within half a mile of Mapleton, to which place it was taken on the next tide on the morning of October 6. It was tied in a protected place in the river opposite Mapleton, where it was not subject to the disturbances to which the other three were liable. On October 8 two more salmon, which had been caught in a gill net near by, were placed in this box, thus increasing the number to 34. Except during the first evening the fish in this box remained quiet and showed no signs of restlessness under the restraint. Boxes 1, 2, and 3 were tied to the piling at the upper end of the wharf at Mapleton. The fish were here occasionally disturbed by persons coming about the boxes or stepping upon them; whether this really increased the mortality or not can not be certainly stated, but it seems reasonable to believe that it would prove detrimental to the fish.

An unusually low tide on October 15 left Box No. 3 about one-third out of water. This seemed to distress the fish, and may have caused some injury. During the latter part of October about 12 more fish were put in No. 1. These had been caught in the gill nets at Mapleton.

The total number of fish which were experimented with was as follows: In Box No. 1, 103; in No. 2, 47; in No. 3, 28; in No. 4, 34. No accurate record was kept of the number of each sex, but at least three fifths of the total number were females.

The mortality among the fish in these different boxes is shown in the following tabular statement:

| Date. | Box No. 1. | Box No. 2. | Box No. 3. | Box No. 4. |
|---|---|---|---|---|
| Sept. 24 | 12 | ..... | ..... | ..... |
| 25 | 4 | ..... | ..... | ..... |
| 26 | 4 | ..... | ..... | ..... |
| 27 | 2 | 1 | ..... | ..... |
| Oct. 1 to 5 | (8) | 2 | ..... | ..... |
| 6 to 12 | (8) | (3) | (3) | 2 |
| 13 to 16 | 8 | ..... | 2 | ..... |
| 17 to 23 | 6 | 6 | 3 | ..... |
| 24 to 27 | 8 | 6 | 4 | 2 |
| Total loss | 60 | 18 | 12 | 4 |
| Percentage of loss | 58 | 38 | 42 | 12 |

After the taking of spawn began, October 26, the fish were shifted about from one box to another, and, though a few continued to die, no accurate record was kept. The mortality was greatest in No. 1 and least in No. 4. The crowded condition of the fish in No. 1 was doubtless a feature which contributed to the loss.

After October 26, when spawn-taking began, the fish were shifted about from box to box, and it was therefore impossible to keep an accurate record of the number dying

lake are being quite rapidly worn away by rough water, forming bluffs. The surface of the lake at one time was somewhat lower than at present; this is evident from the fact that on a shoal place on the east side (near the middle of section 14) stumps of trees are seen some 10 feet below the surface. The former outlet of the lake was into the outlet of Tsiltcoos Lake. A few years ago this outlet became closed by shifting sand, causing the water to rise in the lake at least 6 feet above its present level. A new outlet, a short distance to the east of the old one, was dug to Tsiltcoos Lake some four or five years ago. The new outlet was not only intended to lower the surface of the lake, but to afford a water power for a small sawmill. It has never been so used. The material through which the outlet was dug is a fine clay, so compact that it erodes very slowly. In the extreme ends of the arms of the lake are some tules and small areas of other water-plants.

The surface of Whoahink Lake is about 15 to 20 feet above that of Tsiltcoos Lake, from which it is less than half a mile distant. The timber on the hills bordering the lake was nearly all destroyed by fire some sixty years ago. It is being replaced by a growth of fir, alder, hemlock, maple, rhododendron, huckleberry, and a vigorous growth of ferns. To the west and bordering the sand hills about half a mile distant from the lake are many bull pines. The shore was everywhere so snaggy that a seine could not be used and our collecting apparatus consisted only of gill nets and trot lines. This lake is reported as having very few fishes in it, and our experience confirms this view. The water is clear, though much less so than in the mountain lakes of Idaho; the depth is usually from 30 to 78 feet. The water is not very cold, as may be seen from the following recorded temperatures:

| Date. | Hour. | Temperature of air. | Temperature of water. | | |
|---|---|---|---|---|---|
| | | | Surface. | Depth. | Bottom. |
| 1896. | | °F. | °F. | *Feet.* | °F. |
| Oct. 18 | 4.30 p. m. | 63 | 62 | 54 | 61 |
| 18 | ..... | ..... | ..... | 72 | 56 |
| 19 | 9.30 a. m. | 58 | 61.5 | 30 | 60 |
| 19 | ..... | ..... | ..... | 54 | 61.5 |
| 19 | ..... | ..... | ..... | 66 | 57 |

Tsiltcoos lake is larger and more irregular than Whoahink Lake. The main body of the lake is about 2 miles in extent from north to south, and 1 to 2 miles from east to west. It is also supplied with several arms, usually about a fourth of a mile wide and from ½ to 1½ miles long and extending in different directions. Tsiltcoos Lake is comparatively shallow. In summer its greatest depth is about 17 feet, its average depth being from 10 to 14 feet. During the rainy season the water is from 6 to 10 feet deeper. The bottom is a soft, black mud, like that of Whoahink and Tahkenitch lakes. Except at a few intervals the shore is bordered by a rich growth of tules. In the shallow portions around the shore the tules extend into the lake about a fourth of a mile. There is also considerable swamp vegetation in and about the tules. The surrounding country is quite similar to that around Whoahink. On the east, and at one point on the south, are bluffs of a dark, compact sandstone of much older formation than the bluffs around Whoahink Lake. There are also two timbered islands in this lake, composed of this older sandstone; the larger is about half a mile long and about an eighth of a mile wide. That portion of the country bordering the lake on the south and southwest was not burnt over during the big fire of about sixty years ago.

Tsiltcoos Lake has two inlets, 6 to 8 miles long, Maple Creek at the northeast and 'siltcoos Creek to the southeast corner of the lake. In summer these are little more han small brooks, but during the rainy season they become much swollen and afford spawning-ground for many silver salmon, and possibly a few others, which enter the ake. It is said that about 6 or 7 years ago many more salmon spawned in Maple 'reek than at present.

The outlet of Tsiltcoos Lake is quite small, especially so in summer and at low tide. Gill nets are put across the outlet at low tide and are so anchored and staked down hat it is quite impossible for silver salmon, except the smaller ones, to pass them.

October 17 a number of soundings and temperatures were taken in Tsiltcoos ake. The temperature of the air at 10.15 a. m. was 56°; that of the bottom in various arts of the lake, at depths from 7 to 17 feet, varied from 58.5° to 59.5°.

Tsiltcoos Creek (Ten-mile Creek), the outlet of Tsiltcoos Lake, is about 5 miles ong, while the distance from the lake to the ocean in a direct line is about 2 miles. At ow tide in summer there is barely water enough in the outlet to float a small flat-ottom boat. At high tide the water in the outlet for its entire length is brackish. 'here is some commercial fishing, though the fishing season is short (this year from )ctober 10 to about November 5). Many silver salmon enter the lake, as is evidenced y the number caught in our small gill nets. Fishermen report that salmon are often tranded on the beach. About 100 silver salmon, the first catch of the present season, ·ere brought to the cannery on October 13. There is no reliable evidence that blue-ack salmon are ever found in this lake or its outlet, and only an occasional chinook s found. On October 16 and 17 the bar at the mouth of this creek at low tide com-letely closed the outlet. This prevented salmon from entering and none had been aken since October 13. The fishermen were watching the surf closely to see if many almon were near shore. Ordinarily, if the bar is closed and many fishes are seen in he surf, the fishermen resort to surf fishing until after the bar is opened.

Tahkenitch, or Five-mile, Lake is very irregular in outline. Its greatest length om north to south is about 4½ miles; east to west about the same distance. This ake consists of four large arms whose general directions are with the four cardinal oints. The eastern arm is the longest, the western the shortest, while the other two re about equal in length. The width of these arms varies from about one-eighth o three-quarters of a mile. In the mouth of the smallest arm is a small timbered sland.

Tahkenitch Lake does not lie in the burnt region. The hills surrounding it rise bruptly to a height of usually about 100 feet, and are covered by a dense growth of all fir trees of about 1½ to 3 feet in diameter. In the extreme end of the arms and n a few other places along the shore are found tules and other water vegetation similar o that in Tsiltcoos Lake. The bottom of the lake is a soft, black mud, like that found n the two other lakes. The depth is very uniform, being from 16 to 22 feet.

Five-mile Creek, the outlet of Tahkenitch Lake, has its origin in the distal end of he western arm, its upper end being about 1 mile from the ocean. Its total length is bout twice this distance. The sand hills extend almost to the lake. The isthmus eparating Tahkenitch and Tsiltcoos lakes is rather low and narrow. So far as we ould learn, the commercial fishing on Five-mile Creek is very similar to that on 'en mile Creek. The catch has amounted, according to Hon. A. W. Reed, of Gardiner, o an average of 5,000 silver salmon for each of the past three years.

## UPPER KLAMATH LAKE, OREGON.

In 1889 the United States Fish Commission planted 400,000 whitefish fry (*Coregonus clupeiformis*) in the southern end of Upper Klamath Lake, near Klamath Falls. Ample time having elapsed to enable this species to become well established, observations were made by Messrs. Meek and Alexander for the purpose of determining the result of the plant.

Pelican Bay was reached on the evening of October 31, and work was carried on in the upper part of the lake until November 7, when the camp was moved to the lower end of the lake near the outlet, where the investigations were continued until the 11th. During the time spent at this lake the weather was unusually stormy, and it was exceedingly difficult to carry on the investigations in a manner at all satisfactory. There were only two really good days for work during the entire time.

For the purpose of determining the result of the whitefish plant gill nets of suitable mesh were set in various places in Pelican Bay and in the lower end of the lake. Collections of native fishes were also made, and as much time as possible was given to the study of the fish-food supply of the lake, which was found to be abundant and rich in species of *Entomostraca*, insect larvæ, and other invertebrate life.

The fish life of the lake does not consist of many species, but the individuals of several of the species are very numerous. These will be discussed fully in the list of fishes at the end of this report, but it seems proper to call attention in this connection to the suckers and trout. There are five or six species of suckers in this lake and each of them attains a large size, which renders them of great importance to the Indians on the Klamath Reservation. In the spring of the year, during the spawning time of these fish, vast numbers are caught in traps and by hook and line by the Indians and cured for future use.

The trout are also very common and reach a very large size. Trout weighing 8 to 10 pounds are not at all unusual, examples of 10 to 12 pounds are not rare, and occasionally one weighs as much as 14 pounds. Trout can be taken readily with the fly in the spring and by trolling in the spring and fall. In Pelican Bay they may be taken by trolling at any time.

The Klamath lakes comprise a series of lakes which extend in a north-and-south direction in southern Oregon and northern California. They lie just east of the Cascade Mountains, and are about 4,300 feet above sea level. Our investigations were limited to the largest of these lakes, known as Upper Klamath Lake.

This lake is about 25 miles long and about 8 miles in average width. Its northern half extends in a northwest-and-southeast direction, while its southern half is nearly due north and south. It is quite irregular in outline, having on its western side two large bays, the upper of which forms the northwestern corner of the lake, and is known as Pelican Bay. About 2 miles west of Pelican Bay is a very large spring which forms a prominent creek emptying into the bay. The first half mile of this creek is about 50 to 100 feet wide and from 2 to 8 feet deep. After this it widens out into a large estuary, half a mile or more wide and more than a mile long. On the north this estuary is bordered by a hill, at the foot of which the water is as much as 17 feet deep. The rest of this estuary is bordered by a rich growth of tules and swamp grass. Its depth, except at the north end, seldom exceeds 7 feet, while the greater portion is less than 6 feet in depth. There are, especially on the east side of this estuary, many small narrow arms known as sloughs. These sloughs are about as

deep as the estuary, and each supports a rich growth of *Potamogeton*, *Myriophyllum*, and *Elodea*. These water-plants are also more or less abundant along the water's edge just inside the tules, but are scarce in the main body of the estuary. The water in Pelican Creek and estuary is very clear, and when it is not disturbed the bottom can be plainly seen everywhere. The bottom of the creek and estuary is composed of a light fluffy mud, varying in color from dark grayish to black.

The water in the lake when we saw it was not clear. The fine sediment held in suspension was no doubt picked up from the bottom during rough weather.

The northern portion of Upper Klamath Lake contains many tule islands, and is evidently very shallow. Its shores north of Bare Island are very marshy. The main portion of the lake, or its middle half, is bordered on each side by mountains which rise from the water's edge to an altitude of 1,000 to 1,500 feet above the lake. Toward its southern end the lake becomes narrow. Its shores are mostly marshy and bordered by tules and willows. It also contains considerable water vegetation, the same as at its north end. There are two islands in the lake, Bare Island and Buck Island, each about 500 feet high.

North of the upper end of Upper Klamath Lake is a large area of tule marshes, 6 to 10 miles wide and 10 to 12 miles long. Lying in this marsh is a small lake which has sometimes been improperly called the Upper Klamath Lake. It is now regarded as being only a part of Upper Klamath Lake. It is about 2 miles from the main lake and is about 3 miles wide and 6 miles long. Through this marsh flow several small streams, the principal ones being Seven-mile Creek and Wood River. Williamson River, the principal stream flowing into Upper Klamath Lake, is of considerable size and much importance in its relations to the fishes of the lake. About 10 miles above its mouth it receives from the east a large tributary known as Sprague River. About half a mile above its mouth it is 125 feet wide and 10 feet deep. It flows before entering the lake through a low, flat, marshy plain covered with tules and swamp grass. On the banks of the river is a rich growth of willows. The current is very moderate. We rowed about 2 miles or more up the river and noticed no important change in it. The water in the river was very dark, evidently stained to some extent by vegetation.

The small lake just below Klamath Falls is about ¾ mile wide and 2 miles long. This lake is surrounded by a rich growth of tules and some willows. The depth about half a mile below Klamath Falls was 15 feet. On November 9 the surface temperature was 42¼°; bottom temperature in 15 feet of water, 42¼°. We set one large and two small gill nets in this lake on November 9 and took them up on November 11, obtaining 4 chubs (*Leuciscus bicolor*) and 2 trout.

The outlet of Upper Klamath Lake is Link River, a short stream not over 1¼ miles long, consisting of a series of rapids and falls.

Upper Klamath Lake is a rather shallow body of water. The creek and estuary at Pelican Bay are from 2 to 8 feet deep in the upper part and from 6 to 17 feet in the lower portion. A line of soundings was run across the mouth of the estuary and the depth was found to be about 5½ feet.

Pelican Bay and the north end of the lake are very shallow. A line of soundings was run from the mouth of the estuary of Pelican Creek to the mouth of Williamson River, and 8 feet was the greatest depth found, while the average was not more than 6½ feet. The bottom could be easily seen anywhere when the surface of the water was smooth. It seemed to be composed of loose, decaying vegetation, into which the

sounding lead would usually sink several inches. We were unable to take any soundings in the middle of the lake between Bare and Buck islands. While this is doubtless the deepest portion, we were informed that the water even here probably does not exceed 30 or 40 feet in depth. The south end of the lake is a little deeper than the upper portion. The greatest depth was found near the outlet and was 20 feet. The portion south of Buck Island will not average more than 12 or 13 feet deep.

The temperature observations made at Upper Klamath Lake are given in the table which follows. All the water temperatures except those at the surface were taken at the bottom. Owing to the shallowness of the lake the temperature of its water is everywhere affected by that of the air.

| Date. | Hour. | Station. | Temperature of air. | Depth of water. | Temperature of water. |
|---|---|---|---|---|---|
| | | | ° F. | | ° F. |
| Nov. 2 | 9 a. m. | Near mouth of Pelican Creek | 38 | Surface. | 42 |
| 2 | 9.20 a. m | North end of Pelican Estuary | | do | 40 |
| 2 | 9.20 a. m | Pelican Bay | | 5½ feet | 41½ |
| 2 | 9.20 a. m | do | | 5½ feet | 39½ |
| 2 | 9.20 a. m | do | | 5½ feet | 39½ |
| 3 | 8.45 a. m | Pelican Creek near spring | | Surface. | 44 |
| 3 | 10.45 a. m | Pelican Estuary | | do | 41 |
| 3 | 2.30 p. m | Pelican Creek near spring | 41 | do | 44 |
| 3 | 2.30 p. m | Pelican Estuary | | do | 42½ |
| 4 | 9 a. m. | Pelican Creek near spring | 42 | do | 44 |
| 5 | 9 a. m | Pelican Creek | 42½ | do | 43½ |
| 5 | 10 a. m | Northwest part of Pelican Estuary | | do | 40½ |
| 5 | 10 a. m | do | | 16 feet | 41½ |
| 5 | Noon | Klamath Lake between Pelican Bay and Williamson River. | | Surface. | 42½ |
| 5 | Noon | do | | 7 feet | 43 |
| 5 | 12.30 p. m | do | | Surface. | 42½ |
| 5 | 12.30 p. m | do | | 8 feet | 43 |
| 5 | 1 p. m. | do | | Surface. | 42½ |
| 5 | 1 p. m. | do | | 8 feet | 42 |
| 5 | 4 p. m. | Near mouth of Williamson River | | Surface. | 42½ |
| 5 | 4 p. m. | do | | 10 feet | 42 |
| 5 | 4.30 p. m | Two miles above mouth of Williamson River | | Surface. | 42½ |
| 5 | 4.30 p. m | do | | 10 feet | 42 |
| 6 | 4.30 p. m | At mouth of Pelican Estuary | | Surface. | 39½ |
| 6 | 4.30 p. m | do | | 5½ feet | 40½ |
| 9 | 9 a. m | Small Lake below Klamath Falls | 44 | Surface. | 42½ |
| 9 | 9 a. m | do | | 15 feet | 42½ |
| 10 | 3.30 p. m | South end of Klamath Lake | | Surface. | 41½ |
| 10 | 3.30 p. m | do | | 13 feet | 41½ |

*Character of bottom.*—The large area of tule and marshy lands surrounding the lake has doubtless had much to do in determining the character of the bottom of Upper Klamath Lake. The lake is very shallow, and the vast amounts of decaying vegetation carried into it and the ever-increasing area of tule lands render it more shallow year by year. The bottom, where we examined it, was composed of loose, disintegrating vegetable material, with no sandy or gravelly bottom.

*Fishes.*—Gill nets of suitable mesh were set in this lake in various places, chiefly in Pelican Bay and in the lower end of the lake. A good many trout and chubs and a few suckers were taken, but no whitefish were caught and none was seen anywhere. Inquiry among people at Klamath Falls and elsewhere about the lake failed to elicit evidence that whitefish have ever been seen there since the plant was made. It is to be regretted that nets could not have been set in the middle portion of the lake, as it is there that fish would be found if any have survived. But when it is considered how shallow the lake is, how warm the water probably becomes in summer, and how difficult it would be for whitefish to find suitable spawning-beds, it is doubtful if the eastern whitefish would thrive in such a lake.

*Advantages of a trout-cultural station at Klamath Falls.*—The trout of Upper Klamath Lake are probably not surpassed by any lake-dwelling trout in America in beauty, size, gaminess, or sweetness and delicacy of flavor They are excellent trout to propagate and plant in other lakes. Trout-cultural operations could be carried on at some point on Upper Klamath Lake very advantageously. Perhaps the best location would be at Klamath Falls, where all the engineering conditions are excellent. Fish can be obtained readily and in abundance at any time. A station located upon this lake would be useful in maintaining the supply of trout in it and neighboring lakes and for furnishing fish for planting elsewhere in suitable lakes. The distance of Klamath Falls from the railroad is the chief objection to the establishment of a station at that place.

## CRATER LAKE, OREGON.

In the spring of 1896 the U. S. Commissioner of Fish and Fisheries received a request to plant trout in Crater Lake, Oregon. This request was made by citizens of Medford, Ashland, and Klamath Falls, and by the Mazamas, a club of mountain climbers with headquarters at Portland, whose members take an active and intelligent interest in discovering and making known the scenic and other natural attractions of the Northwestern States. Before complying with the request, the Commissioner decided to have made such investigations as would determine whether the physical and biologic conditions existing at Crater Lake are such as will permit fish to thrive in it. These investigations were made by Professor Evermann and Prof. U. O. Cox, of Mankato, Minnesota.

Crater Lake is about 100 miles from the nearest railroad station, and is reached by a wagon road, which has a number of steep, rough grades. The Mazamas had selected this lake as the place of their annual meeting for 1896, and the Fish Commission party by their invitation made the trip to the lake with them, thus obviating the necessity of employing special conveyances and making the trip comparatively inexpensive. The party left Ashland by wagon August 13 and reached the lake on the morning of August 19. Work was carried on at the lake until August 24, when the party set out upon the return trip to Ashland, which was reached August 26.

Crater Lake* lies in the top of Mount Mazama and on the very summit of the Cascade Range, about midway between Mount Shasta and Mount Hood. Its latitude is 42° 56′ N. and its longitude is 122° 7′ W. In many respects it is one of the most interesting natural wonders in America. It is approximately circular and averages a little more than 5 miles in diameter. It is completely encircled by a bold escarpment ranging from 500 to 2,000 feet in height above the surface of the water. Although the steep slopes of the escarpment are in some places well wooded, they are generally either cliffs or talus, descending to the lake and plunging into deep water. There are many places where the walls are almost perpendicular, and at only two or three places is it possible to descend to the water's edge. The lake has practically no shores or beaches; only in a few places is there sufficient beach to afford standing room. The average diameter of this great pit at the top is 5.7 miles and its depth is 4,000 feet. The highest part of the wall surrounding this lake is 8,228 feet above sea level, while the surface of the lake is 6,239 feet above the sea.

* In our general description of this lake we have made free use of the excellent account given by Mr J. S. Diller, of the U. S. Geological Survey. Mr. Diller has made a careful topographic survey of the region and possesses a thorough and intimate acquaintance with Crater Lake.

The rim of the basin now occupied by Crater Lake is the present summit of what was once a mountain cone. That this is simply the frustum of what was once a complete mountain cone is evidenced by the attitude of the sheets of lava and ejected volcanic material which form the rim. They all incline away from the lake, indicating a common source from a crater that surmounted a huge volcano high in air above the place now occupied by the lake. At that time, of course, neither basin nor lake existed. Mr. Diller thinks that this great volcanic mountain, recently named Mount Mazama, must have extended about 5,000 feet higher than the remaining fragment, thus making its height about 14,000 feet, nearly that of Mount Shasta. What became of the top of Mount Mazama is an interesting question. The geologists are convinced that at some period in its history the molten interior, instead of escaping through the crater in the usual way, found an outlet at a lower level. The top of the mountain being thus left a mere shell and without adequate support, fell in and became engulfed in the vast pit which the lake now partly fills. The pumice upon the surface for many miles around Crater Lake was probably blown out by the volcano before the pit developed, and the volcano of Wizard Island was active at a much later stage upon the bottom of the pit. It was the scene of the last eruption about the lake, and, although recent in appearance, must have occurred centuries ago.

Crater Lake is, so far as known, the deepest lake in America. Many soundings have been taken by the United States Geological Survey. Over only very limited areas was a depth of less than 1,000 feet found, while over a large part of the lake the depth ranges from 1,800 to 2,000 feet. In the eastern portion of the lake is a great level floor, with a nearly uniform depth of 2,000 feet for a distance of more than 3 miles. In the western part are three or more small cones, one reaching within 93 feet of the surface of the water, while another rises 845 feet above the water. This is Wizard Island, a perfect cinder cone, with symmetrical slopes, and in its top a crater 80 feet deep. This cone is composed chiefly of red lapilli, and so new and fresh that it is sparsely forested and shows no trace of weathering. About the base of this island cone is a rough fringe of lava, which has spread in all directions to far beneath the water's level. The shallowest parts of the lake lie west and south of Wizard Island. The average depth in this area probably does not exceed 150 feet.

Crater Lake has neither inlet nor visible outlet. The catchment area is scarcely greater than the lake itself. During the summer season several streams trickle down the walls from the snow banks which lie within the rim; these streams are all very small, but a few of them continue throughout the summer, as some of the snow banks lying on the southern walls never entirely disappear. The amount of precipitation is believed to be greater than the evaporation, but the level of the lake does not appear to be rising. It is therefore quite probable that there is a subterranean outlet, and the large springs in the vicinity of Fort Klamath may have their source in Crater Lake.

The water of Crater Lake is cold, fairly pure, and exceedingly clear. Though sufficiently pure for all fish-cultural purposes, it is slightly flat to the taste and doubtless contains some minerals in solution. Froth or foam readily forms when the water is disturbed. The clearness is remarkable, an ordinary dinner plate being distinctly visible at a depth of nearly 100 feet, even in a hazy atmosphere.

The color of the lake is a wonderful blue, except in certain comparatively shallow places near the shore. In the deeper parts of the lake it is the most intense blue we have ever seen; from there toward the shore, and in the changing light and shadows of

cliffs and clouds, the colors change from ultramarine through cobalt and azure blue to smalt blue and hyacinth, and even to royal purple, violet, and mauve. So marvelously and strangely beautiful are these colors that one never tires watching and studying them. The general effect as one views the lake from some advantageous point upon the rim is profoundly impressive. Two thousand feet below lies the lake in whose placid blue waters everything is so perfectly mirrored that one can not tell where the real ends and the mirror begins. Near the west shore rises Wizard Island, symmetrical and beautiful in all its proportions, while around the lake is a circle of 20 miles of nearly perpendicular wall, hundreds of feet high and unrivaled in its scenic effects.

*Temperatures.*—Considerable time was devoted to the making of temperature observations in different parts of the lake and at different depths.

The following table gives the surface temperatures recorded:

| Date. | Hour. | Station. | Temperature. |
|---|---|---|---|
| 1896. | | | ° F. |
| Aug. 19 | 4 p. m. | From shore in Eagle Cove | 59 |
| 20 | 9.40 a. m. | One-fourth mile from shore in Eagle Cove | 57 |
| 20 | 9.55 a. m. | One mile from shore in Eagle Cove | 56.5 |
| 20 | 10 10 a. m. | One-fourth mile from Wizard Island | 58 |
| 20 | 1.40 p. m. | One-fourth mile off Phantom Ship | 60 |
| 21 | 8.45 a. m. | From shore in Eagle Cove | 55.6 |
| 22 | 9.11 a. m. | ....do | 56 |
| 22 | 1 p. m. | Near center of lake | 62 |
| 22 | 3 p. m. | About 2¼ miles east of Wizard Island | 61 |
| 22 | 4 p. m. | ....do | 61 |

The following intermediate and bottom temperatures were taken, with a Negretti-Zambra deep-sea thermometer tripped by means of a propeller, such as is used by the *Albatross* in her deep-sea temperature work:

| Date. | Hour. | Station. | Depth. | Temperature. |
|---|---|---|---|---|
| 1896. | | | *Feet.* | ° F. |
| Aug. 20 | 11 a. m. | At bottom ½ mile south of Wizard Island | 93 | 43.5 |
| 20 | 1.40 p. m. | At bottom ½ mile off Phantom Ship | 866 | 44 |
| 22 | 3 p. m. | About 2¼ miles east of Wizard Island | 555 | 39 |
| 22 | 4 p. m. | ....do | 1,040 | 41 |
| 22 | 5 p. m. | At bottom 2¼ miles east of Wizard Island | 1,623 | 46 |

The vertical series taken on August 22, at a station about 2¼ miles east from the southeast corner of Wizard Island, proved of very great interest. The surface temperature was 61°; at 555 feet it was 39°; at 1,040 feet 41°; and at 1,623 feet, which was at the bottom, 46°. In all other American lakes, so far as known, the coldest water in summer is always at the bottom. The effect of the sun in heating the water of lakes does not ordinarily reach to any great depth. Observations recently made upon Lake Champlain by Prof. George C. Whipple and our own observations made in 1896 upon Alturas and Wallowa lakes showed that the sun's heat did not much affect the temperature of the water beyond a depth of 100 feet.

If there be no error in the above observations, it seems that the waters of Crater Lake are still receiving heat from the rock upon which they rest. The heat of the old volcano has not entirely disappeared. The coldest water is neither at the surface nor at the bottom, but at some intermediate depth. The results of these observations are so unexpected, and the indicated conditions are so unusual, that the matter should receive further attention. The only possible source of error which has yet suggested

itself is that the propeller may not always have worked properly. It is possible (though improbable) that in some cases, when beginning to haul up the thermometer the propeller failed to reverse until some moments later, in which case the temperature reading would be for some depth other than the one desired. The observations should be carefully repeated before the conclusions suggested are accepted.

During the trip of the Mazama party from Ashland to Crater Lake and return a good many temperature observations were made. All of these possess a certain value and it has been thought proper to record them in this connection. The air temperatures were all in the shade unless otherwise stated. The instrument used was a Wilder protected thermometer.

*Miscellaneous temperatures recorded on the Crater Lake trip, August 13 to 26, 1896.*

| Date. | Hour. | Station. | Air. | Water. | Date. | Hour. | Station. | Air. | Water. |
|---|---|---|---|---|---|---|---|---|---|
| | | | ° F. | ° F. | | | | ° F. | ° F. |
| Aug. 13 | 9.10 p. m. | Hunt's ranch, 4,400 feet elevation. | 54 | ..... | Aug. 18 | 5.00 a. m. | Creek at Crane Creek camp. | ..... | 41 |
| 14 | 5.00 a. m. | .....do ..... | 41 | ..... | 18 | ....do ..... | Air at Crane Creek camp. | 36 | ..... |
| 14 | 9.10 p. m. | Camp at Lake of the Woods. | 61 | ..... | 18 | 8.30 a. m. | Wood River at bridge. | ..... | 45 |
| 15 | 5.00 a. m. | .....do ..... | 46 | ..... | 18 | 6.30 p. m. | Camp 2½ miles from Crater Lake, 6,100 feet. | ..... | 43 |
| 15 | 12.18 p. m. | Creek on way to Mount Pitt. | ..... | 54 | | | | | |
| 15 | 2.00 p. m. | Spring on creek on way to Mount Pitt. | ..... | 42.75 | 19 | 5.25 a. m. | .....do ..... | 49 | 39 |
| 16 | 4.00 a. m. | Camp on side of Mount Pitt. | 50 | ..... | 19 | 1.20 p. m. | Camp Mazama, Crater Lake, 7,185 feet. | 66 | ..... |
| 16 | 9.42 a. m. | Summit of Mount Pitt, 9,760 feet. | 55 | ..... | 19 | 3.00 p. m. | Small stream on trail down to lake. | ..... | 45 |
| 16 | 11.30 a. m. | Summit of Mount Pitt, 9,760 feet, in sun. | 83 | ..... | 19 | 11.00 p. m. | Camp Mazama..... | 56 | ..... |
| 17 | 4.40 a. m. | Camp returning from Mount Pitt. | 37 | ..... | 20 | 6.00 a. m. | .....do ..... | 54 | ..... |
| 17 | 12.30 p. m. | Large spring at Pelican Bay. | ..... | 43 | 20 | 12.00 m. | .....do ..... | 67.5 | ..... |
| 17 | ....do ..... | Small spring at Pelican Bay. | ..... | 43.5 | 20 | 10.00 p. m. | .....do ..... | 52 | ..... |
| 17 | ....do ..... | Creek 100 yards below spring at Pelican Bay. | ..... | 44.75 | 21 | 6.00 a. m. | .....do ..... | 51 | ..... |
| 17 | ....do ..... | Creek 400 yards below spring at Pelican Bay. | ..... | 45.5 | 21 | 8.45 a. m. | .....do ..... | 58 | ..... |
| 17 | ....do ..... | Creek at entrance of Pelican Bay. | ..... | 47 | 21 | 2.30 p. m. | .....do ..... | 61 | ..... |
| 17 | ....do ..... | Air in shade at Pelican Bay. | 77 | ..... | 21 | 8.00 p. m. | .....do ..... | 58.5 | ..... |
| 17 | 2.14 p. m. | .....do ..... | 80 | ..... | 21 | 10.20 p. m. | .....do ..... | 55 | ..... |
| 17 | 8.00 p. m. | Crane Creek camp, 3,900 feet. | 52 | ..... | 22 | 6.00 a. m. | .....do ..... | 52 | ..... |
| 17 | 10.20 p. m. | .....do ..... | 44 | ..... | 22 | 9.00 a. m. | .....do ..... | 66 | ..... |
| 17 | ....do ..... | Creek at Crane Creek camp. | ..... | 41.5 | 22 | 4.00 p. m. | .....do ..... | 59 | ..... |
| | | | | | 23 | 7.35 a. m. | .... do ..... | 65 | ..... |
| | | | | | 23 | 9.00 a. m. | Camp Mazama, Cathedral Spring. | 66 | 35.5 |
| | | | | | 23 | 12.20 p. m. | Camp Mazama..... | 69.5 | ..... |
| | | | | | 23 | 3.00 p. m. | .....do ..... | 70.5 | ..... |
| | | | | | 23 | 9.00 p. m. | .....do ..... | 59 | ..... |
| | | | | | 24 | 5.00 a. m. | .....do ..... | 62 | ..... |
| | | | | | 24 | 9.00 p. m. | Rogue River camp, 2,300 feet elevation. | 61 | ..... |
| | | | | | 25 | 5.50 a. m. | Rogue River camp.... | 46 | ..... |
| | | | | | 25 | 9.00 p. m. | Jackson's ranch camp, 1,300 feet. | 65 | ..... |
| | | | | | 26 | 6.00 a. m. | Jackson's ranch camp. | 57 | ..... |

*Life of Crater Lake.*—Crater Lake contains no fishes; lakes without inlets or outlets seldom or never do, for fishes naturally get into one body of water only by swimming to it from some other body of water with which it is connected. Fishes never appear *de novo* in any lake or stream; if they appear there at all it is because they can swim there from some other lake or stream. Breaks in water continuity, or even considerable falls, are absolute barriers beyond which fishes can not go. So with Crater Lake; it has never had any inlet or visible outlet connecting it with any other body of water in which fishes are found and through which fishes might reach it.

Mammals and birds excepted, only 3 species of vertebrates were found within the rim of Crater Lake, viz, a snake, a frog, and a salamander.

The snake is the small-headed striped snake, *Thamnophis leptocephalus* (Baird & Girard). Two specimens were obtained on Wizard Island. It was not seen elsewhere.

One frog, *Rana aurora* Baird & Girard, was also obtained on Wizard Island. Others were seen about the spring below the camp. The salamander is *Amblystoma macrodactylum* Baird. It is by far the most abundant and most interesting vertebrate occurring at Crater Lake. Our first specimens were found on the shore under Redcloud Cliffs, where we found it to be exceedingly abundant. It was afterwards found in considerable numbers along the shore in Eagle Cove and a few were obtained about Wizard Island. More than a hundred specimens were collected and many more could have been obtained. The majority of the individuals seen were adults, only 4 or 5 still retaining the external gills were seen. These salamanders were found under the rocks just above the edge of the water of the lake. Sometimes as many as a dozen or fifteen were found under a single flat stone. These three species are not uncommon throughout western Oregon and Washington.

Invertebrate life was found to be fairly abundant, and a few plants were found. By using fine-meshed surface towing nets considerable collections were made. The following is a list of the species obtained:

PLANTS.

*Algæ:*
- *Nostoc* sp.? Colonies common.
- *Melosira granulata*. Not common.
- *Pleurosigma* sp.? Several specimens.
- *Surirella* sp.? Not common.

ANIMALS.

*Crustacea:*
- *Cyclops albidus*. Not common.
- *Cyclops serrulatus*. Not common.
- *Daphnia pulex pulicaria*. Very abundant.
- *Allorchestes dentata*. Not common.

*Insecta:*
- *Chironomus* sp.? Larvæ. Very common.
- *Ephemerid* larvæ. Common.
- *Limnophilus* or caddis fly. Very abundant.

ANIMALS—Continued.

*Insecta*—Continued.
- *Laccophilus* larvæ. Not common.
- *Deronectes striatellus*. Common.
- *Dytiscus* sp.? Not rare.

*Vermes:*
- *Gordius* sp.? One specimen obtained.
- A species of leech. Not common.

*Mollusca:*
- *Physa* sp.? Not common.

*Batrachia:*
- *Amblystoma macrodactylum*.
- *Rana aurora*.

*Reptilia:*
- *Thamnophis leptocephalus*.

These crustaceans and insect larvæ are all excellent food for trout, and were found in considerable abundance, particularly in Eagle Cove. The small entomostracan, *Daphnia pulex pulicaria*, was the most abundant species, and large numbers could be seen during favorable afternoons swimming at the surface in Eagle Cove. The three other species of crustaceans seemed far less abundant.

Caddis-fly cases were very abundant on the under sides of rocks lying in the edge of the water. A small black leech was quite common on the rocks in Eagle Cove and about Wizard Island. The small gastropod (*Physa*) was found about Wizard Island in limited numbers, a species of water-beetle (*Dytiscus*) was pretty common, and a single specimen of *Gordius*, or hair snake, was found near the shore of the island.

There are no water-plants of any size in the lake. On the rocks about Wizard Island the gelatinous masses of colonies of *Nostoc* were common. A number of specimens of the diatom, *Pleurosigma*, were obtained in the towing net, and a few specimens of two other algæ were secured.

Summing up the matter, it may be said that while the conditions at Crater Lake are not the most favorable to fish-life, there seems to be no reason why trout in limited numbers might not thrive in it. The water is all that could be desired as to purity and temperature, but the depth is so uniformly great that only small areas of bottom suitable for spawning-beds are found. The entire absence of all other fish-life and the

very limited vegetation supported by the lake reduce the food supply almost wholly to small free-swimming crustaceans and insect larvæ. Both are present in considerable abundance, but probably not in sufficient quantities to support a large number of fishes. On the other hand, fishes planted in this lake will have no rapacious fishes with which to contend; the struggle will, therefore, be wholly with the physical environment and the food supply. It has, therefore, been recommended that a plant of trout be made in Crater Lake, and it is hoped that the Mazamas who visit the lake hereafter may make observations to determine the result of the experiment. The best species to plant is the black-speckled trout of Lake Tahoe, *Salmo mykiss henshawi*.

## LIST OF FISHES.

In the following list of fishes we give only those species of which specimens were obtained by us during the investigations of 1896. In the nomenclature and sequence of species we follow Jordan & Evermann's Check-List,* recently published:

**1. Entosphenus tridentatus** (Gairdner). *Three-toothed Lamprey.*

A specimen, 18 inches long, was obtained July 23 in Alturas Inlet, 1 mile above the lake, and several larvæ were dug out of the sand at the head of the lake July 25. Comparing the large specimen with one 24 inches long, obtained by Mr. Williams at Big Payette Lake, some important differences are noted. In the Payette example the dorsal fins are separated by a space equal to one-third the length of the base of the anterior fin, while the Alturas example has the dorsals scarcely separated. The fins are also much higher in this specimen, the height of the anterior dorsal being contained 3¼ times in head, measured to first gill-opening, or 1⅓ times in the height of the second. The infraoral lamina has 5 cusps; the supraoral has 3, the middle one being much smaller than the other two; the buccal teeth before the mouth are unicuspid; on each side of the oral opening are 4 teeth, the anterior and posterior ones of which are bicuspid, while the other two are tricuspid. The arrangement of the teeth does not differ materially from that in the Payette specimen. The larvæ range from 1¼ to 3½ inches in total length. In all of these the dorsal fin is continuous, though deeply incised.

An example 10¾ inches long was found attached to a chub in Upper Klamath Lake, November 10.

**2. Acipenser medirostris** Ayres. *Green Sturgeon.*

Common near the mouth of Siuslaw River; several taken in a seine near Acme in September, measuring about 18 inches each in total length. At Gardiner, near the mouth of the Umpqua, a good many large sturgeon, probably *A. transmontanus*, were taken in November and December.

**3. Pantosteus jordani** Evermann. *Western Black Sucker.*

During the season's work this sucker was found only in Wallowa Lake, Oregon. Two small specimens were obtained in the upper end of the lake August 24.

**4. Catostomus tsiltcoosensis, new species.**

Type No. 48479, U. S. Nat. Mus.; cotypes No. 38, U. S. F. C., and No. 5703, L. S. Jr. Univ. Mus.

Type locality: Tsiltcoos Lake, Lane County, Oregon, where numerous specimens were obtained December 2, 1896, by Dr. Meek.

Apparently most closely related to *C. occidentalis* Ayres.

Head 4½; depth 5; eye 6½ in head; snout 2; D. 13; A. 7; scales 13–65–8, 34 before the dorsal. Pectoral 1⅓ in head; longest dorsal ray 1⅔; base of dorsal 1⅔; longest anal ray 1½; ventral 1⅔. Body rather slender, subterete; head small, snout long and pointed; mouth inferior, overhung by the projecting snout; lips rather thin, one row of large papillæ on upper lip, and about 2 irregular rows of smaller ones behind or inside of it; lower lip incised nearly to base, 1 or 2 rows of small papillæ across the isthmus; lobes of lower lip moderately long and thin, the bases with papillæ merging into plications toward the tips. Eye quite small, the anterior edge of orbit at middle of head. Top of head flat or very slightly convex between the eyes. Fins small; pectorals short and rounded;

*A Check-List of the Fishes and Fish-like Vertebrates of North and Middle America, in Report U. S. F. C. for 1895 (December 28, 1896), 207–590.

ventrals short, rounded, the middle rays but little longer than the others; anal small, somewhat pointed; margin of dorsal slightly concave; caudal lunate, not deeply forked. Muciferous canals on head not strongly developed. Scales moderately large; lateral line nearly straight, not running upward toward nape.

Length of type, 8 inches to base of caudal.

The cotypes agree closely with the type in all characters of importance.

We have compared our specimens of this species with specimens of *C. occidentalis* (Fig. 2) from the Sacramento River and find important differences. Comparing examples of the same size, we find that *C. tsiltcoosensis* has a smaller head, longer, more pointed snout, smaller eye, larger scales, and much smaller fins; the pectorals in *C. occidentalis* are falcate while in this species they are more rounded, and the ventrals also are less pointed.

An example of *C. occidentalis* 9 inches long has the head 4¼; depth 5; eye 5½; snout 2½; D. 12; A. 7; scales 13–70–10, 41 before the dorsal.

This species is abundant in Tsiltcoos Lake and Siuslaw River. The specimens from Siuslaw River were obtained in brackish water.

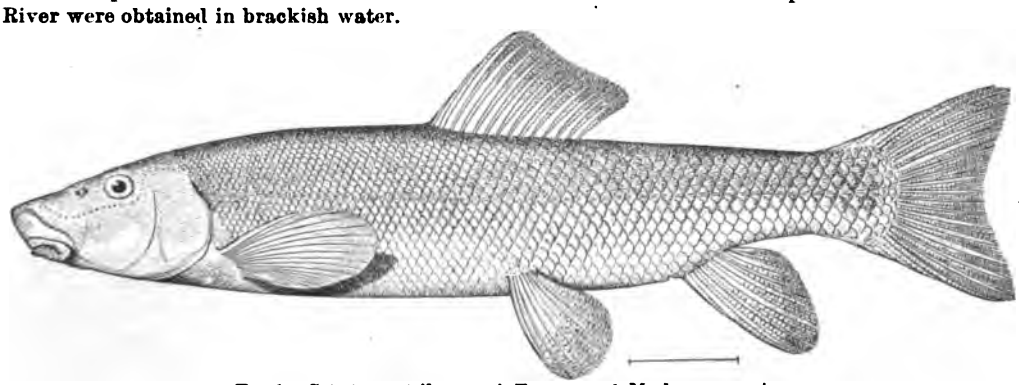


FIG. 1.—*Catostomus tsiltcoosensis* Evermann & Meek, new species.

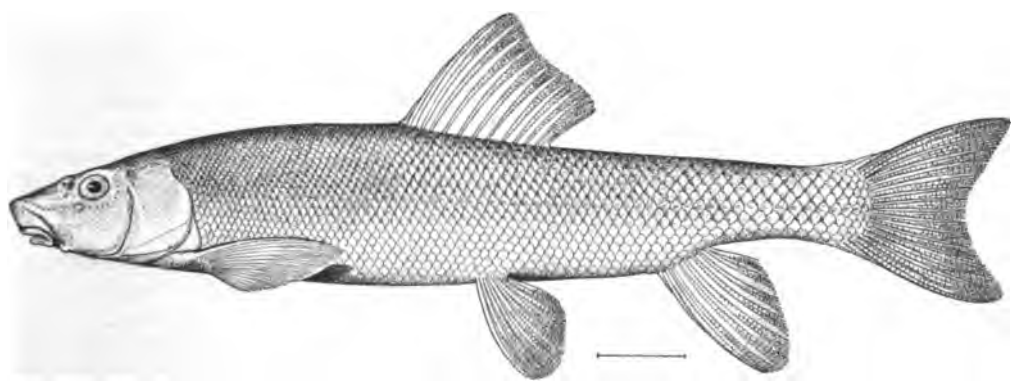


FIG. 2.—*Catostomus occidentalis* Ayres.

**5. Catostomus macrocheilus** Girard. *Columbia River Sucker; "Yellow Sucker."*

Abundant throughout entire Columbia River basin; obtained this year from Alturas and Wallowa lakes, in both of which it is abundant. It seems not to occur in Siuslaw River, nor in lakes of that part of Oregon. Five specimens from Lake Union near Seattle, and one from Lake Washington at Seattle.

**6. Catostomus snyderi** Gilbert.

One obtained from an Indian at the mouth of Williamson River, November 5. This species was caught, along with *Chasmistes copei* and *Chasmistes stomias*, in the small trap or basket nets which the Indians were using at that place. Three small specimens, 2¾ to 4¾ inches long, were taken in the seine at the south end of Upper Klamath Lake November 10, and two others, 2 and 2½ inches long, respectively, in a slough at Pelican Bay November 3. No large examples seen in shallow water.

The Klamath Lake *Catostomus* has been identified, by all who have had occasion to mention it, with *C. labiatus* Ayres, upon the supposition that the type of Ayres's species came from Klamath Lake. But Ayres plainly states* that it came from Stockton, California. As only one species of this genus is found in San Joaquin River, *C. labiatus* becomes a synonym of *C. occidentalis*, and the Klamath Lake species is left without a name, a fact first pointed out by Mr. J. O. Snyder, for whom the fish has been recently named by Dr. Gilbert.†

The type specimen upon which Dr. Gilbert based his description is less than 8 inches long. As the one which we have from the mouth of Williamson River is much larger (length, 14¼ inches) and shows some slight differences, we describe it fully as follows: Head 4⅓; depth 4; eye 6½ in head; snout 2½; maxillary 3⅓; mandible 2⅓; interorbital 2⅛; width of mouth 3½ in head, more than half length of snout; greatest width of lower lip ⅔ diameter of eye; D. ii, 11; A. 7; scales 13–70–11. Body rather slender; head long, mouth moderate, horizontal; lips thick papillose, the upper with about 4 or 5 rows of papillæ, lower with about 7; lower lip divided nearly to base, leaving only one row of papillæ crossing the symphysis; premaxillary not much projecting and not forming a prominent hump; maxillary rather short, not reaching vertical at front of anterior nostril; eye equally distant between snout and posterior edge of opercle; mucous canals on head forming raised ridges, the pores conspicuous. Fins moderate; origin of dorsal a little nearer snout than base of caudal, sixth spine over insertion of ventrals; pectoral 1½ in head, reaching slightly more than two-thirds distance to ventrals; ventrals not quite reaching vent, the seventh ray longest, 1⅔ in head; anal long, pointed, reaching to base of caudal, 1⅛ in head. Scales crowded anteriorly, about 32 transverse rows in front of dorsal, strongly ridged, the margins crenate.

**7. Chasmistes stomias** Gilbert.

One specimen, 15 inches long, obtained from an Indian at Klamath Falls, November 11. Head 4⅛; depth 4½; eye 7; snout 2⅔; maxillary (measured from free end to tip of snout) 3⅛; mandible 2½; D. ii, 11; A. i, 7; scales 13–85–10; interorbital width 2½; vertical depth of head at mandibular articulation 2⅛. Head small, body heavy forward, the back strongly and regularly arched from snout to origin of dorsal fin, thence declined in a nearly straight line to base of caudal; ventral surface nearly straight. Premaxillary spines strongly protruding, forming a prominently projecting snout; mouth rather small, inclined upward at an angle of about 40°, maxillary scarcely reaching vertical from front of anterior nostril; width of mouth 1⅔ in snout or 4⅓ in head; upper lip thin, without papillæ; lower lip thin, interrupted at the symphysis, forming narrow lateral lobes the width of which is about 2⅔ times in their length; faint indications of a few papillæ; mucous canals forming ridges, the pores conspicuous; gill-rakers long, narrowly triangular at the tip when viewed from behind, densely tufted on the anterior edge; fontanelle narrow, its length 2⅔ in the snout, its width about ⅓ its length. Fins all large; the origin of the dorsal a little nearer tip of snout than base of caudal, the sixth ray over base of ventral, its base 1⅔ in head, the free edge nearly straight, the last ray 1⅔ in the first, which is 1½ in head; pectorals scarcely falcate, reaching a little more than two-thirds distance to base of ventrals, their length 1½ in head; ventrals long, reaching vent, the rays gradually increasing in length from the outer to the seventh and eighth, which are longest, the ninth and tenth being but slightly shorter, the length of the longest ray 1⅔ in head or about ⅓ longer than the first; anal long and pointed, the fourth ray longest, reaching base of caudal, 1⅛ in head; each ray of anal fin with 8 to 12 strong tubercles; caudal lobes about equal, their length 1⅔ times the middle ray.

This specimen agrees with Dr. Gilbert's type,‡ with which we have compared it. In the type the mouth is rather more oblique, the maxillary is slightly longer, and the anal fin is longer.

**8. Chasmistes copei**, new species. Klamath Indian name "*Tswam.*"

Type No. 48224, U. S. N. M. (collectors' No. 871), a specimen 16 inches long. Type locality Northwest part of Pelican Bay, Upper Klamath Lake, Oregon; collected (in gill net) November 6, 1896, by Messrs. S. E. Meek and A. B. Alexander.

Head 3⅔; depth 4; eye 6⅓; snout 2½; maxillary (measured from free end to tip of snout) 3; mandible 2⅔; D. ii, 10; A. i, 7; scales 13–80–12; interorbital width 2½; vertical depth of head at mandibular articulation 2½. Head large, cheek very deep, the depth equal to distance from tip of snout to nostril; body stout, back scarcely elevated, caudal peduncle rather short and stout; ventral surface somewhat convex. Premaxillary spines less protruding than in *C. stomias*, not forming a prominent

*Proc. Cal. Ac. Nat. Sci., I, 1855, 33.
†Bull. U. S. F. C. 1897, 3.
‡Described in Bull. U. S. F. C. 1897, 5, with figure.

hump; mouth large, inclined upward at an angle of 45°, maxillary not nearly reaching vertical at front of anterior nostril; width of mouth 1⅓ in snout, or 4 in head; upper lip thin, without papillæ; lower lip thin, entirely without papillæ, interrupted at symphysis, forming rather broad lateral lobes; pores on head very conspicuous; gillrakers larger than in *C. stomias*, broadly triangular at tip when viewed from behind, densely tufted on anterior edge, each appendage more or less bifid and club shaped, closely resembling those of *C. liorus;* fontanelle narrow, its length 2½ in snout, width one-fifth its length. Fins all small; origin of dorsal a little nearer snout than base of caudal, its sixth ray over base of ventrals, free edge straight, base 2½ in head, last ray a little less than 2 in first, which is 2 in head; pectorals somewhat falcate, reaching slightly more than half distance to ventrals, their length 1⅔ in head; ventrals very short, reaching only two-thirds distance to vent, free end nearly straight; outer ray longest, 2⅔ in head; inner shortest, 3½ in head; anal fin short, bluntly pointed, not reaching base of caudal, third and fourth rays longest, 1⅞ in head; no tubercles on anal rays; caudal lobes equal, length about 1⅞ times the middle ray. Scales small and crowded anteriorly, about 14 rows downward and backward from front of dorsal to lateral line, 11 vertically upward from base of ventral to lateral line, about 38 oblique series before dorsal; lateral line nearly straight, with about 80 scales. Entire upper parts of head and body, and sides nearly to level of base of pectorals, dark olivaceous; under parts abruptly whitish or yellowish in alcohol; a dark spot in upper part of axil; dorsal and caudal dark; pectorals dark on inner surface; ventrals and anal plain.

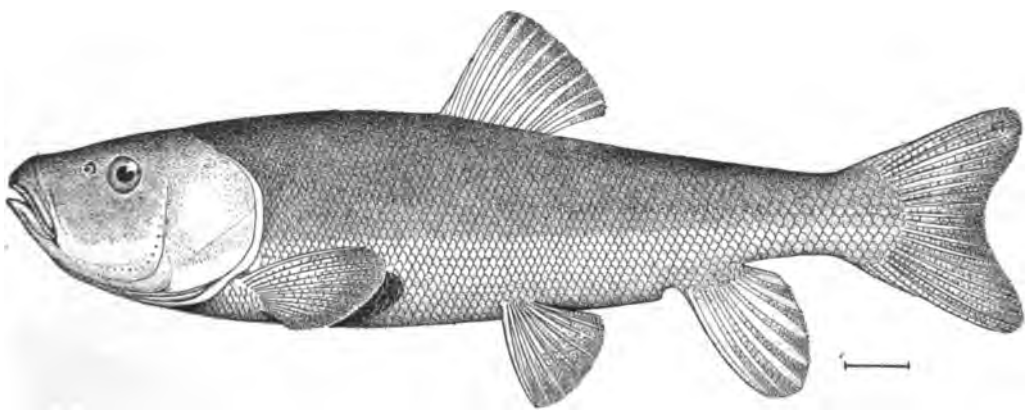


FIG. 3.—*Chasmistes copei* Evermann & Meek, new species.

From *Chasmistes stomias* this species is readily distinguished by its larger head, larger, more oblique mouth, less prominent snout, and very small fins. The differences in the fins are very great, particularly in the ventrals, as may be seen in the accompanying illustrations. It differs from *C. brevirostris*, as characterized by Dr. Gilbert, in its much larger, more oblique mouth, the absence of papillæ on the lips, and shorter fins.

We name this species for the late Prof. Edward Drinker Cope, who wrote the first paper on the fishes of Upper Klamath Lake.

Six nominal species of suckers have thus far been described from the Klamath Lakes, viz: *Chasmistes luxatus* and *Chasmistes brevirostris* by Cope in 1879; *Catostomus rex* by Rosa Smith Eigenmann in 1891; *Catostomus snyderi* and *Chasmistes stomias* by Gilbert, and *Chasmistes copei* by Evermann & Meek, the last three in the present Bulletin. Mr. A. Seale has recently taken *C. luxatus* as the type of his new genus *Deltistes*, which he bases upon the peculiar structure of the gillrakers. Dr. Gilbert finds that *Catostomus rex* is a synonym of *Deltistes luxatus*. As now understood, we therefore know from Upper Klamath Lake one species of *Catostomus*, one of *Deltistes*, and three of *Chasmistes*.

**9. Mylocheilus caurinus** (Richardson). *Columbia Chub.*

Obtained from Little White Salmon River, Lakes Washington and Sammamish at Seattle, and Lake Pend d'Oreille at Hope, Idaho. Abundant early in September in lagoon at mouth of Little White Salmon River, and seen in considerable numbers at steamboat landings between Portland and The Dalles. It does not occur in the Redfish Lakes in Idaho, nor has it been recorded from Wallowa Lake, nor from any of the streams or lakes south of the mouth of the Columbia.

**10. Ptychocheilus oregonensis** (Richardson). *Squawfish; Yellowbelly.*

This large minnow is abundant throughout the Columbia River basin except the portion above Shoshone Falls. In Montana, and perhaps elsewhere, it is called "squawfish"; at Sawtooth, Idaho, it is known only as "yellowbelly"; at Mapleton, Oregon, "chub" was the only name heard applied to it; while at Tsiltcoos Lake it was called "dace." Specimens obtained from Lakes Alturas, Pend d'Oreille, Gamlin, Washington, Tsiltcoos, Whoahink, and Tahkenitch, and from Siuslaw River. One was taken on a set line in Whoahink Lake, at a depth of 78 feet, on December 3.

*Scale and fin formulæ and comparative measurements of specimens of P. oregonensis from Lake Washington.*

| Length in inches. | Head. | Depth. | Eye. | Snout. | Dorsal. | Anal. | Scales. | Length in inches. | Head. | Depth. | Eye. | Snout. | Dorsal. | Anal. | Scales. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 7.25.. | 3.64 | 5.33 | 5.60 | 1.80 | 10 | 9 | 76 | 5.25... | 3.78 | 5.00 | 5.00 | 1.42 | 10 | 9 | 77 |
| 7.75.. | 3.67 | 5.00 | 5.80 | 2.00 | 10 | 9 | 80 | 5.00... | 3.60 | 4.86 | 5.25 | 1.67 | 10 | 9 | 74 |
| 7.00.. | 3.50 | 5.00 | 5.60 | 1.80 | 10 | 9 | 77 | 4.63... | 3.83 | 4.75 | 5.00 | 1.67 | 10 | 9 | 76 |
| 5.75.. | 3.57 | 5.00 | 5.17 | 1.67 | 10 | 9 | 74 | 4.38... | 3.83 | 4.67 | 4.67 | 1.50 | 10 | 9 | 74 |
| 5.88.. | 3.44 | 5.00 | 5.00 | 1.50 | 10 | 9 | 74 | 4.38... | 3.67 | 4.67 | 5.00 | 1.50 | 10 | 9 | 77 |
| 5.50.. | 3.67 | 5.00 | 5.00 | 1.50 | 10 | 9 | 75 | 3.17... | 3.60 | 4.60 | 4.60 | 1.40 | 10 | 9 | 78 |

**11. Leuciscus bicolor** (Girard).

Judging from our collections, this is the most abundant minnow in Upper Klamath Lake. About 60 were obtained at the lower end of the lake November 10, and over 100 from a small creek at Pelican Bay November 5. At the time of collecting this species was found in the shallow water of the little creeks and passages among the tules. The largest are 9 to 10 inches long, but only a few exceed 3 inches. Examples 2 to 3 inches long gave the following measurements: Head 4; depth 5; eye $3\frac{1}{2}$ to $3\frac{3}{5}$; snout $4\frac{2}{5}$ to $4\frac{1}{2}$; scales 59; teeth 2, 5–5, 2. See illustration on page 7 of this Bulletin.

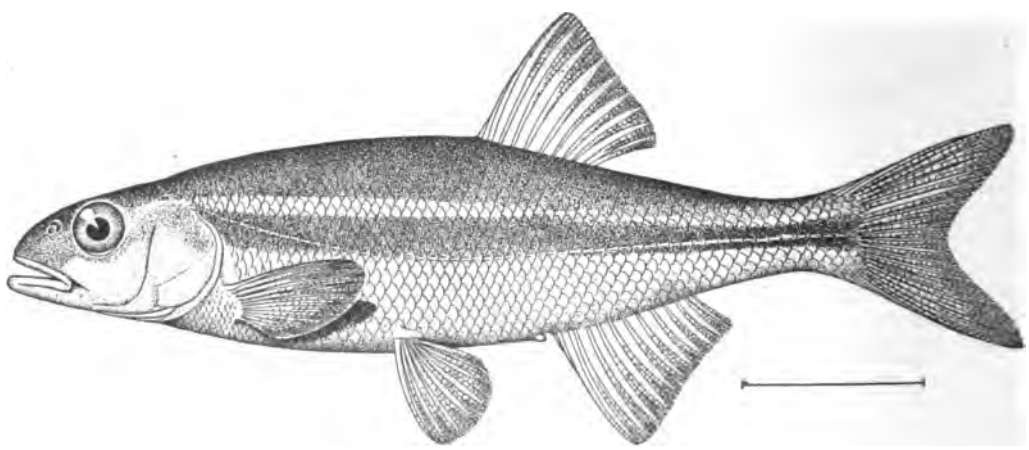


FIG. 4.—*Leuciscus siuslawi* Evermann & Meek, new species.

**12. Leuciscus siuslawi**, new species.

Type No. 48480, U. S. N. M., a specimen 5 inches long. Cotypes No. 433 U. S. F. C.; No. 48231, U. S. N. M., and No. 5702, L. S. Jr., Univ. Mus. Type locality: Siuslaw River at Mapleton, Oregon. Collected September 8, 1896, by S. E. Meek.

Head $4\frac{1}{2}$; depth $4\frac{1}{6}$; eye 4; snout $3\frac{1}{2}$; maxillary $3\frac{2}{5}$; D. ii, 9; A. ii, 12 or 13; scales 11–58–8; teeth 2, 4–5, 2, somewhat hooked.

Body rather slender, slightly elevated and somewhat compressed; head small and pointed, cheek not deep; snout pointed, somewhat longer than eye; mouth moderate, somewhat oblique, maxillary just reaching vertical at front of orbit; jaws subequal, the lower sometimes slightly projecting; eye large, not as great as snout. Origin of dorsal fin behind base of ventrals and much nearer base of caudal than tip of snout, the longest ray $1\frac{1}{2}$ in head, greater than base of fin; origin of anal fin under

last dorsal ray but two, its height equal to that of dorsal, its base equal to its longest ray; free edges of dorsal and anal nearly straight; pectoral 1¼ to 1⅓ in head, not reaching insertion of ventrals; ventrals short, 1⅓ in pectoral, reaching anus; caudal deeply forked; lateral line complete, decurved; color in spirits, brownish or olivaceous above, middle of side with a broad dark band involving the lateral line anteriorly and posteriorly, but lying chiefly above it mesially; middle of side from gill opening to beneath dorsal fin with a broad rosy band, following closely beneath the lateral line; lower part of sides and under parts silvery, dusted over with fine dark specks; a light yellowish band extending backward from upper posterior border of eye nearly halfway to origin of dorsal fin; cheek with a silvery or golden crescent; top of head dark; opercles dusky silvery; snout dusky; fins plain, dorsal and caudal somewhat dusky. Numerous specimens were obtained in the Siuslaw River and one from Tsiltcoos Lake.

At Mapleton both this minnow and *Ptychocheilus oregonensis* are known as "chub," while on the lakes south of Florence they are called "dace." It is probably common in these lakes, but a single specimen only was obtained there.

Compared with *Leuciscus balteatus*, which our specimens most closely resemble, the latter are seen to have smaller anal and dorsal fins, a more slender body, smaller and more slender head, and longer, more pointed snout. The extent of variation in proportional measurements and in the number of anal fin rays appears to be much less than in *L. balteatus*.

This species also resembles *Leuciscus cooperi* of Girard. In the type of *L. cooperi* (No. 238, U. S. N. M.) the lower jaw is notably shorter and the snout more pointed.

In the following statement will be found measurements of a number of specimens from Siuslaw River, Mapleton, Oregon:

| Total length | Head. | Depth. | Eye. | Snout. | Dorsal. | Anal. | Scales. | Total length | Head. | Depth. | Eye. | Snout. | Dorsal. | Anal. | Scales. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Inches.* | | | | | | | | *Inches.* | | | | | | | |
| 5.75 | 4.20 | 4.17 | 4.00 | 3.50 | 9 | 13 | 11–58–7 | 4.50 | 4.00 | 3.83 | 3.50 | 3.50 | 9 | 12 | 10–60–7 |
| 5.50 | 4.00 | 4.00 | 4.00 | 3.60 | 8 | 11 | 12–59–7 | 4.50 | 4.00 | 4.00 | 3.80 | 3.50 | 9 | 12 | 10–59–7 |
| 5.50 | 4.00 | 4.17 | 4.00 | 3.60 | 9 | 13 | 10–59–7 | 4.50 | 4.00 | 4.40 | 3.40 | 3.80 | 9 | 12 | 10–61–7 |
| 5.50 | 4.17 | 4.17 | 4.00 | 3.60 | 9 | 13 | 12–64–6 | 4.50 | 4.00 | 3.80 | 3.80 | 3.75 | 9 | 13 | 10–59–7 |
| 5.25 | 4.00 | 4.00 | 4.00 | 3.75 | 8 | 12 | 12–60–7 | 4.25 | 4.00 | 4.00 | 3.60 | 3.80 | 9 | 11 | 10–63–6 |
| 5.00 | 4.00 | 3.80 | 3.50 | 3.60 | 8 | 13 | 12–60–7 | 4.00 | 4.00 | 4.00 | 3.20 | 4.00 | 9 | 13 | 10–61–7 |
| 4.50 | 4.00 | 4.17 | 3.50 | 3.50 | 9 | 13 | 12–64–6 | | | | | | | | |

The anal fin rays were counted in 16 additional specimens with the following results, the average for the total 29 specimens being 12¼:

| Total length. | No. of anal rays. | Total length. | No. of anal rays. | Total length. | No. of anal rays. |
|---|---|---|---|---|---|
| *Inches.* | | *Inches.* | | *Inches.* | |
| 5.75 | 11 | 2.50 | 13 | 2.63 | 13 |
| 5.75 | 13 | 2.25 | 12 | 2.63 | 13 |
| 3.00 | 12 | 2.25 | 12 | 2.63 | 13 |
| 3.00 | 13 | 2.81 | 12 | 2.50 | 14 |
| 2.50 | 13 | 2.75 | 13 | 2.13 | 13 |
| | | | | *a* 4.63 | 12 |

*a* From the outlet of Tsiltcoos Lake.

**13. Leuciscus balteatus** (Richardson).

Abundant throughout the Columbia River basin except above Shoshone Falls. Specimens obtained from Alturas, Pend d'Oreille, Gamlin, and Washington lakes. The variation in the number of anal fin rays of specimens from these localities is shown in the following table. The length is measured from tip of snout to base of caudal fin. The last ray, though usually deeply divided, is counted as one. There are usually two rudimentary rays at front of fin, which are not counted. Of 30 specimens from Gamlin Lake, 1 has 13 rays, 7 have 15, 14 have 16, 4 have 17, and 4 have 18, the average being 16 rays. Of 10 specimens from Lake Washington 5 have 14 rays, 3 have 15, 1 has 16, and 1 has 18, the average being 15 rays.

*Table showing variation in the number of rays in the anal fin in Leuciscus balteatus.*

| Gamlin Lake. | | | | | | Lake Washington. | |
|---|---|---|---|---|---|---|---|
| Length in inches. | Anal. | Length in inches. | Anal. | Length in inches. | Anal. | Length in inches. | Anal. |
| 1.88 | 16 | 1.63 | 16 | 1.75 | 16 | 2.75 | 15 |
| 1.88 | 16 | 1.50 | 16 | 1.75 | 18 | 3.13 | 14 |
| 1.88 | 16 | 2.00 | 18 | 1.75 | 15 | 2.50 | 14 |
| 1.88 | 17 | 2.13 | 15 | 2.00 | 16 | 3.13 | 15 |
| 1.75 | 15 | 1.75 | 17 | 2.00 | 16 | 3.13 | 14 |
| 2.00 | 16 | 1.88 | 16 | 1.63 | 18 | 3.50 | 14 |
| 1.88 | 15 | 1.88 | 18 | 1.88 | 16 | 3.50 | 16 |
| 1.75 | 16 | 1.75 | 15 | 1.75 | 13 | 4.00 | 15 |
| 1.75 | 17 | 1.75 | 17 | 1.50 | 15 | 3.75 | 18 |
| 1.63 | 16 | 1.75 | 15 | a4.75 | 16 | 3.88 | 14 |

a From Lake Pend d'Oreille.

**14. Rutilus bicolor** (Girard).

Numerous specimens obtained in a slough at Pelican Bay and others at the south end of Upper Klamath Lake. Some were caught in a gill net, others in a small dip net, such as is used by Klamath Indians; a few were taken on a set line, but the majority were obtained by means of a small seine, in small sloughs or lagoons at the south end of Upper Klamath Lake. It seems to be one of the most abundant species occurring in the lake. The largest measure about 9 inches in total length. There does not appear to be much variation in the number of scales or fin rays, or in proportional measurements, as is shown in the following table. The Indians use this species for bait when fishing for trout near Klamath Falls, the average length of those thus used being about 4 inches. It is caught in large numbers in dip nets in the edge of the tules. This species is figured on page 8 of this Bulletin.

*Table showing variation in 13 specimens of Rutilus bicolor from Upper Klamath Lake, Oregon.*

| Length in inches. | Head. | Depth. | Eye. | Snout. | Maxillary. | Dorsal. | Anal. | Scales. |
|---|---|---|---|---|---|---|---|---|
| 9.00 | 3.75 | 3.75 | 7.00 | 3.50 | 4.00 | 9 | 8 | 49 |
| 9.25 | 3.75 | 3.67 | 6.00 | 3.50 | 3.75 | 9 | 8 | 49 |
| 6.00 | 3.75 | 3.75 | 5.50 | 3.75 | 4.25 | 9 | 8 | 48 |
| 4.50 | 4.00 | 4.00 | 4.50 | 4.00 | 4.20 | 9 | 8 | 47 |
| 4.50 | 3.75 | 3.75 | 4.50 | 4.00 | 4.25 | 9 | 8 | 48 |
| 4.25 | 4.00 | 4.00 | 4.50 | 4.00 | 4.25 | 9 | 8 | 46 |
| 5.25 | 3.50 | 4.00 | 5.00 | 3.50 | 4.33 | 9 | 8 | 48 |
| 3.75 | 3.50 | 4.00 | 4.25 | 3.67 | 4.25 | 9 | 8 | 49 |
| 3.75 | 3.50 | 4.00 | 4.50 | 4.00 | 4.00 | 9 | 8 | 44 |
| 3.50 | 3.50 | 3.75 | 4.25 | 4.00 | 4.50 | 9 | 8 | 46 |
| 3.50 | 3.50 | 4.25 | 4.20 | 4.00 | 4.33 | 8 | 7 | 47 |
| 3.50 | 3.67 | 4.25 | 4.00 | 4.00 | 4.25 | 9 | 7 | 47 |
| 2.50 | 3.60 | 4.33 | 3.50 | 4.50 | 4.25 | 9 | 8 | 46 |

**15. Rhinichthys dulcis** (Girard).

One specimen from Wallowa Lake. The origin of the dorsal is midway between tip of snout and base of caudal peduncle.

**16. Agosia klamathensis**, new species

Type No. 48225, U. S. N. M.; cotypes No. 5704, L. S. Jr. Univ. Mus. and No. 451, U. S. F. C. Type locality at mouth of the small creek which flows into the arm of Upper Klamath Lake called Pelican Bay, where numerous specimens were collected November 3, 1896, by Dr. Seth E. Meek and Mr. A. B. Alexander. Length of type 2½ inches, measured to last caudal vertebra.

Close to *Agosia nubila*.

An examination of a large series of specimens of *Agosia* from Upper Klamath Lake and a comparison of them with specimens of *A. nubila* from various localities show the fish from this lake to possess certain characters which serve to distinguish it from typical *A. nubila*. While the differences are slight, they are plainly evident and must be recognized, and we therefore describe this form as a new species.

Head 4; depth 4½; eye 4½ in head; snout 3½. D. i, 8; A. i, 7; scales about 14–78–10 (average, 73 in 49 specimens).

Body robust, subcylindrical, back somewhat elevated; snout rather long, mouth inferior, little oblique, the lower jaw included; maxillary not reaching front of orbit; upper lip without frenum; barbel present, but small. Lateral line incomplete, interrupted in many places, about 30 pores developed. Origin of dorsal fin midway between front of pupil and base of caudal fin; pectorals rather short, reaching about three-fourths the distance to base of ventrals; ventrals reaching vent; anal large, its longest ray 1½ in head; caudal widely forked.

Color in alcohol, olivaceous, mottled and blotched with darker on back and sides; under parts pale; an obscure pale streak from eye to base of caudal fin, below which is a broad dark band; dorsal, pectorals, and caudal dusky; other fins plain; a black blotch at base of caudal.

An examination of the 48 specimens which we designate as cotypes shows all the important characters to be fairly constant. The barbel is in a few cases obscure or possibly absent. The number of scales in a transverse line varies from 68 to 78, the average being 73. The lateral line is in all cases incomplete, though in different degrees; sometimes it is continuous for only 6 or 8 scales, after which there are several interruptions and only 8 to 10 more pores; in others there are 20 to 30 pores in a continuous series.

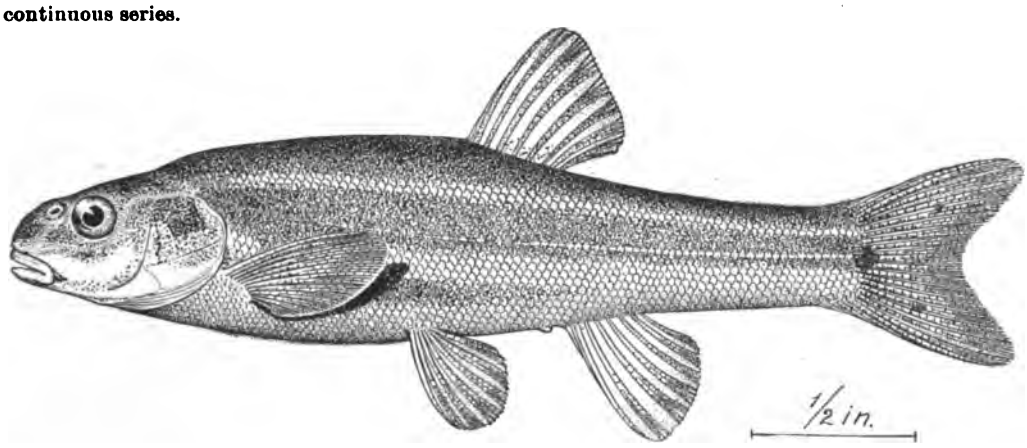



FIG. 5.—*Agosia klamathensis* Evermann & Meek, new species.

This form is distinguished from *Agosia nubila* chiefly by the smaller size of the scales. This difference will appear from an examination of the tabular statement which follows:

*Table showing number of scales in Agosia nubila and Agosia klamathensis.*

| Locality. | No. of specimens examined. | Variation in number of scales. | Average number of scales. |
|---|---|---|---|
| *Agosia nubila:* | | | |
| Colville River, Meyers Falls | 6 | 52–57 | 55 |
| Little Spokane River, Dart's Mill | 9 | 52–63 | 62 |
| Hangman Creek, Tekoa, Wash. | 10 | 51–65 | 57 |
| Lake Cœur d'Alene | 9 | 64–70 | 66 |
| Newaukum River, Chehalis | (?) | 53–58 | 55 |
| Boise River, Caldwell | 1 | 56 | 56 |
| Potlatch Creek, Lewiston | 10 | 60–66 | 62 |
| Pataha River, Starbuck | 9 | 60–64 | 62 |
| Walla Walla River, Wallula | 15 | 47–55 | 49 |
| Mill Creek, Walla Walla | 20 | 52–61 | 55 |
| Umatilla River, Pendleton | 3 | 48–58 | 52 |
| Columbia River, Umatilla | 7 | 48–57 | 53 |
| Natchess River, North Yakama | (?) | 53–58 | 56 |
| Shookumchuck River, Chehalis | 6 | 50–57 | 55 |
| *Agosia klamathensis:* | | | |
| Pelican Bay, Upper Klamath Lake | 49 | 68–78 | 73 |

**17. Clupanodon cæruleus** (Girard). *California Sardine.*

Very abundant in Siuslaw River about the cannery wharf at Florence during the canning season. It seems to disappear as soon as the fall rains set in and the river becomes filled with fresh water. The specimens seen were each about 2½ inches in length.

*Chinook salmon taken in fish-wheels by Mr. I. H. Taffe, Celilo, Oregon, September 18 to 22, 1896.*

| Date. | Males. | | Females. | | Total. |
|---|---|---|---|---|---|
| | Number. | Well developed. | Number. | Well developed. | |
| 1896. | | | | | |
| Sept. 18 | 19 | 10 | 9 | 9 | 28 |
| 19 | 8 | 5 | 10 | 6 | 18 |
| 21 | 18 | 11 | 35 | 26 | 53 |
| 22 | 12 | 8 | 8 | 6 | 20 |
| | 57 | 34 | 62 | 47 | 119 |

Among the 119 chinook salmon, 13 small ones were found, all males, and their milt as fully developed as that in larger fish. Sometimes the wheels take these fish in considerable numbers.

*Chinook salmon taken by Mr. F. A. Seufert, at Celilo, Oregon, September 25 to October 13, 1896.*

| Date. | Males. | | Females. | | Total. |
|---|---|---|---|---|---|
| | Number. | Well developed. | Number. | Well developed. | |
| 1896. | | | | | |
| Sept. 25 | 82 | 67 | 64 | 61 | 146 |
| 26 | 15 | 11 | 17 | 17 | 32 |
| 27 | 109 | 82 | 89 | 76 | 198 |
| 28 | 56 | 47 | 70 | 63 | 126 |
| 29 | 56 | 50 | 49 | 44 | 105 |
| Oct. 2 | 60 | 50 | 76 | 73 | 136 |
| 5 | 122 | 105 | 148 | 144 | 270 |
| 7 | 63 | 55 | 67 | 65 | 130 |
| 10 | 43 | 38 | 51 | 51 | 94 |
| 13 | 77 | 69 | 88 | 64 | 165 |
| | 683 | 574 | 719 | 658 | 1,402 |

In a total of 683 males and 719 females Mr. Alexander found 574 males and 658 females which, in his judgment, were nearly ripe. In other words, 84 per cent of the males and 90 per cent of the females would have spawned between the first and middle of October. These observations indicate that chinook salmon can be obtained abundantly at Celilo by wheels and that if retained a few days they would be ripe enough for stripping. Whether the wheels seriously injure the fish can be determined only after actual experiment with fish so caught. If the wheels do not injure them they can probably be kept until fully ripe in properly constructed retaining boxes or ponds, as was demonstrated by experiments at Mapleton, Oregon.

According to Mr. Alexander chinook salmon appear in the lower part of Puget Sound about the 1st of May and continue to increase in numbers until July. Scattering ones are taken, however, throughout the year in all parts of the sound.

**22. Oncorhynchus kisutch** (Walbaum). *Silver salmon.*

Our collection contains specimens of this species as follows:

Three ripe males, one 16 inches in length, caught December 1 in Whoahink Lake, the other two, 16 and 17½ inches respectively, December 3, in Tsiltcoos Lake. Specimens of this size and very much smaller were frequently caught in the seine at Acme. Not less than 50 of these were examined. All were males with sexual organs as highly developed as in the larger ones.

One large ripe male from Tsiltcoos Lake, caught in a gill net December 3, 1896. Immaculate, back with a bluish tinge, body bright red, mouth much distorted. Locally called "hookbilled silverside."

There is a moderately small form of the silver salmon in the Siuslaw River called blueback, which resemble the true blueback in size, form, and color, but are more spotted. Two specimens, 8¾ and 10 inches in length respectively, from Tsiltcoos Lake near outlet, December 2, 1896. Back, brownish blue; dorsal, nearly black, darker on posterior part; pectorals, light brownish; ventrals, white; anal fin with a dark shade. These specimens were probably hatched during the winter of 1894–95.

Two specimens from Seattle, Washington, 10½ inches in length.

Six mature specimens from Union Lake near Seattle, Washington, 4 males and 2 females.

Of the small specimens, no doubt hatched during the winter of 1895–96, our collection contains the following:

Two specimens, 2⅛ and 3½ inches in length respectively, hatched during the winter of 1895–96 by Mr. L. E. Bean at Mapleton and retained in a small spring brook until September 9, 1896.

One, 3¾ inches long, caught in a seine in Siuslaw River below Florence December 8, 1896.

Two specimens, 5¼ and 5⅝ inches respectively, caught with a seine in Tsiltcoos Lake December 1, 1896. All three with parr marks present; no red on sides; dorsal, adipose, and caudal fins yellowish; caudal reddish near tips; pectoral and ventrals yellowish.

During the latter part of September and early part of October Mr. Alexander was at Celilo, on the Columbia River, and made some valuable observations upon the silver salmon. He examined a total of 2,268 fish of this species, all of which he found well advanced, indicating to him that they would spawn before the middle of October.

*Silver salmon examined by Mr. Alexander at Celilo.*

| Date. | Male. | | Female. | | Total. |
|---|---|---|---|---|---|
| | Number. | Well developed. | Number. | Well developed. | |
| **Taken in wheels by Mr. Taffe:** | | | | | |
| Sept. 18, 1896 | 5 | 2 | 1 | 0 | 6 |
| Sept. 19, 1896 | 6 | 4 | 2 | 1 | 8 |
| Sept. 21, 1896 | 9 | 7 | 13 | 8 | 22 |
| Sept. 22, 1896 | 11 | 8 | 8 | 6 | 19 |
| | 31 | 21 | 24 | 15 | 55 |
| **Taken in seines by Mr. Seufert:** | | | | | |
| Sept. 26, 1896 | 136 | 112 | 149 | 135 | 285 |
| Sept. 27, 1896 | 157 | 146 | 186 | 160 | 343 |
| Sept. 28, 1896 | 117 | 97 | 123 | 114 | 240 |
| Sept. 29, 1896 | 102 | 73 | 115 | 83 | 217 |
| Oct. 2, 1896 | 137 | 123 | 166 | 145 | 303 |
| Oct. 5, 1896 | 149 | 105 | 144 | 123 | 293 |
| Oct. 7, 1896 | 96 | 83 | 127 | 119 | 223 |
| Oct. 10, 1896 | 68 | 63 | 86 | 78 | 154 |
| Oct. 13, 1896 | 49 | 41 | 106 | 91 | 155 |
| | 1,011 | 843 | 1,202 | 1,048 | 2,213 |

Silver salmon first appear in the southern end of Puget Sound about the 1st of September, and the run usually lasts until the first or middle of November. A few individuals are taken as late as December, after which few are seen in the sound, but a good many are caught in Duwamish River.

**23. Oncorhynchus nerka** (Walbaum). *Blueback Salmon; "Redfish"; "Sockeye."*

The investigations made in Idaho in 1894 and 1895 resulted in settling some of the disputed questions concerning the redfish, but left others still in doubt. The details of the observations made in those years will be found in the reports already published.* A summary of the conclusions reached regarding the life-history of the redfish is given on page 16 of this article.

Although no satisfactory evidence was obtained as to the occurrence of the small form anywhere in the stream below the lakes, this was not considered proof that it does not come up from the sea. So close is its resemblance to the native trout, except at spawning time, that it would probably not attract the attention of anyone, even if seen below the lakes.

In order to obtain more definite results in the study of this problem, the redfish lakes of Idaho were again visited in 1896. Camp was established July 11, on Alturas Lake Creek at the crossing of the trail a short distance below Perkins Lake. Gill nets were set in the outlet the same day and were kept set until September 25. These nets were examined from day to day during the entire period of seventy-six days and not a single redfish was caught in them. The water was so high and the current so swift during the first ten days the nets were set that it was impossible to place them so as to wholly obstruct the stream. It is therefore possible that fish may have ascended the stream and passed the nets

*A Preliminary Report upon Salmon Investigations in Idaho in 1894, by Barton W. Evermann, Bull. U. S. F. C. 1895, 253–284.

A Report upon Salmon Investigations in the Headwaters of the Columbia River, in the State of Idaho, in 1895; together with Notes upon the Fishes observed in that State in 1894 and 1895, by Barton W. Evermann, Bull. U. S. F. C. 1896, 149–202, plates 67–72.

during that time. This, however, is improbable. Our camp was situated upon the bank of the stream, the water was at all times very clear, and we were able to keep close watch for fish. If any redfish had come up during those ten days it is more than probable they would have been seen by some of us. After July 22 these nets were examined usually about three times each week, and though other fishes, such as yellowbellies, Dolly Varden trout, suckers, and whitefish, were caught by them, no redfish, either large or small, were taken. But small redfish were in the lake at least as early as July 16, and they began entering the inlet August 3. Between August 3 and August 28 the number in the inlet increased rapidly until the latter date, when 1,569 were counted.

The first small redfish seen was caught on a hook in Alturas Lake, just off the inlet, July 16, by Mr. Maddren, while fishing for Dolly Varden trout. The hook was baited with salmon spawn. This fish was a male 11¼ inches in total length, and the stomach contained a small amount of insect larvæ. Of the many examples, taken by a gill net in Alturas Inlet on August 6, 9 were examined, only one of which showed any trace of food in the stomach.

Twelve specimens, caught with grab-hook in Wallowa Lake about the 1st of September by Mr. J. J. Stanley, were all quite fat, and food was found in the stomachs of all but three. This food consisted chiefly of small crustaceans, a few insect larvæ, and some gelatinous alga, probably a *Nostoc*.

Among the fishes from Lake Washington are 5 redfish, 3 of which are 7 to 8 inches long, the other 2 about 4 inches each. These were all collected June 15 by Mr. Alexander. Each contains more or less food in the stomach. Two other small redfish were obtained, which had been taken on the fly by Mr. E. L. Kellogg while fishing in Lake Sammamish about May 15.

Whether this fish is anadromous or not is an exceedingly difficult matter to determine. If it comes up from the sea it reaches the lakes much earlier in the summer or spring than has hitherto been supposed. The fact that it feeds while in the lakes is now fully established, and it apparently continues to feed almost or quite to the time when it runs into the inlets for spawning. The one with food in its stomach, taken in Alturas Inlet August 6, had just reached the inlet on that night. The specimens from Wallowa Lake were caught in the upper end of the lake near the inlet, which they doubtless would have ascended in a few days.

A consideration of small redfish from different localities, as to their size, proves interesting and suggestive. Those from Alturas Lake are larger and much more uniform in size than those from other places. Those from Washington, Stuart, and Nicola lakes are somewhat smaller, while those from Wallowa Lake are much smaller. These differences in size are, in some cases, doubtless due to differences in age, the specimens having been taken earlier at some of the lakes than at others, but the marked difference between the Alturas and Wallowa specimens can not be accounted for on this basis. It is doubtful if any of the Wallowa individuals would have reached even the minimum size of those taken at Alturas Lake. This fact is brought out in the following table. In the first column are given lengths in inches, the length being measured to the tip of the caudal fin; in the other columns are given the number of fish of each length from the respective lakes named at the head of the columns.

*Table showing comparative sizes of specimens of the small redfish from different lakes.*

| Length in inches. | Alturas. | Wallowa. | Washington. | Stewart. | Nicola. | Chilowey-uck. | Total number. |
|---|---|---|---|---|---|---|---|
| 7.00 | ..... | 2 | ..... | ..... | ..... | ..... | 2 |
| 8.00 | ..... | 1 | ..... | ..... | ..... | ..... | 1 |
| 8.25 | ..... | 1 | ..... | ..... | ..... | ..... | 1 |
| 8.50 | ..... | 4 | ..... | ..... | ..... | ..... | 4 |
| 8.75 | ..... | 1 | ..... | ..... | 1 | ..... | 2 |
| 9.00 | ..... | 1 | ..... | 2 | ..... | ..... | 3 |
| 9.25 | ..... | ..... | 1 | ..... | ..... | ..... | 1 |
| 9.50 | ..... | 1 | ..... | ..... | 1 | ..... | 2 |
| 9.75 | ..... | ..... | 3 | ..... | 2 | ..... | 5 |
| 10.00 | ..... | ..... | 4 | 1 | ..... | ..... | 5 |
| 10.25 | 4 | ..... | 5 | 1 | ..... | ..... | 10 |
| 10.50 | 4 | ..... | 4 | ..... | ..... | 2 | 10 |
| 10.75 | 6 | ..... | ..... | ..... | ..... | ..... | 6 |
| 11.00 | 9 | ..... | ..... | ..... | ..... | ..... | 9 |
| 11.25 | 15 | ..... | ..... | ..... | ..... | ..... | 15 |
| 11.50 | 39 | ..... | ..... | ..... | ..... | ..... | 39 |
| 11.75 | 20 | ..... | ..... | ..... | ..... | ..... | 20 |
| 12.00 | 19 | ..... | ..... | ..... | ..... | ..... | 19 |
| 12.25 | 6 | ..... | ..... | ..... | ..... | ..... | 6 |
| 12.50 | 4 | ..... | ..... | ..... | ..... | ..... | 4 |
| | 126 | 11 | 17 | 4 | 4 | 2 | 164 |

*Table of comparative measurements of small redfish from Alturas and Wallowa lakes.*

| Wallowa Lake. | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| No. | Length in inches. | Sex. | Head. | Depth. | Eye. | Snout. | Maxillary. | Scales. |
| 102 | 9.38 | Male.... | 4.00 | 4.00 | 5.00 | 4.20 | 1.90 | 130 |
| 103 | 8.50 | ...do .... | 3.90 | 4.00 | 5.00 | 3.80 | 2.00 | 130 |
| 104 | 7.13 | ...do .... | 4.00 | 4.00 | 4.67 | 4.00 | 1.85 | 127 |
| 105 | 7.00 | ...do .... | 4.20 | 4.00 | 4.50 | 4.60 | 2.00 | 128 |
| 106 | 8.75 | ...do .... | 4.00 | 4.00 | 4.75 | 4.00 | 2.00 | 126 |
| 107 | 8.13 | ...do .... | 4.00 | 4.00 | 4.67 | 4.50 | 2.00 | 127 |
| 108 | 8.38 | ...do .... | 4.00 | 3.75 | 4.83 | 4.00 | 2.00 | 120 |
| 109 | 9.00 | ...do .... | 4.00 | 4.00 | 4.75 | 4.50 | 2.00 | 126 |
| 110 | 8.63 | ...do .... | 4.00 | 4.00 | 4.50 | 4.16 | 2.00 | 128 |
| 111 | 8.25 | ...do .... | 3.83 | 4.00 | 4.80 | 4.00 | 2.00 | 122 |
| 112 | 8.63 | ...do .... | 4.00 | 4.10 | 5.00 | 4.00 | 2.00 | 126 |
| 113 | 6.38 | ...do .... | 4.40 | 4.50 | 4.25 | 5.25 | 2.10 | 125 |
| 155 | 5.25 | ...do .... | 4.40 | 4.50 | 4.33 | 5.25 | 2.13 | 124 |
| Alturas Lake. | | | | | | | | |
| No. | Length in inches. | Sex. | Head. | Depth. | Eye. | Snout. | Maxillary. | Scales. |
| 786 | 11.50 | Male.... | 4.50 | 4.33 | 4.25 | 4.50 | 2.00 | 126 |
| 788 | 12.00 | ...do .... | 3.80 | 4.00 | 5.00 | 3.50 | 1.80 | ..... |
| 807 | 12.50 | ...do .... | 3.75 | 4.00 | 5.25 | 3.33 | 1.75 | ..... |
| 803 | 11.50 | ...do .... | 3.80 | 4.20 | 5.00 | 3.33 | 1.80 | ..... |
| 808 | 12.00 | Female . | 4.13 | 4.50 | 4.50 | 4.00 | 2.00 | ..... |
| 811 | 12.25 | Male.... | 4.20 | 4.40 | 5.00 | 3.67 | 1.83 | ..... |
| 810 | 12.50 | ...do .... | 3.80 | 4.20 | 5.20 | 3.50 | 1.80 | ..... |
| 783 | 12.25 | ...do .... | 3.75 | 4.33 | 5.25 | 3.25 | 1.80 | ..... |
| 813 | 11.50 | Female . | 4.17 | ..... | 5.00 | 4.00 | 2.00 | ..... |

Specimen No. 155 was found dead on the shore at head of lake; specimens Nos. 113 and 155 with undeveloped sexual organs.

**alvelinus malma** (Walbaum). *Dolly Varden Trout; Western Charr; Bull Trout.*

btained in Alturas, Pend d'Oreille, and Wallowa lakes, where it is abundant and affords good for the angler. At Alturas Lake during July a great many were caught about the mouth of the and many large examples were taken in Lake Pend d'Oreille. The charr is a voracious fish and largely upon other species of fishes. In the stomachs of some of those examined at Lake Pend lle were numerous specimens of *Leuciscus balteatus, Ptychocheilus oregonensis, Mylocheilus caurinus, ptus.* All of these except *M. caurinus* were found in the stomach of one fish. Some specimens his lake were infested about the axils by a small crustacean of the genus *Lernæopoda.*

easurements of a number of specimens of charr are given in the following table:

*Comparative measurements of charr from the Columbia River Basin.*

| Length in inches. | Head. | Depth. | Eye. | Snout. | Maxillary. |
|---|---|---|---|---|---|
| *a* 12.50 | 3.80 | 4.80 | 6.40 | 4.00 | 2.00 |
| *a* 18.50 | 3.40 | 6.00 | 7.50 | 3.00 | 1.60 |
| *b* 12.25 | 3.53 | 5.00 | 6.60 | 3.60 | 1.85 |
| *c* 6.50 | 4.20 | 5.00 | 5.25 | 4.00 | 1.85 |
| *c* 5.50 | 4.00 | 4.75 | 5.00 | 4.00 | 2.00 |
| *d* 11.50 | 4.00 | 5.50 | 7.00 | 3.83 | 2.00 |
| *d* 10.50 | 4.00 | 6.00 | 6.00 | 3.83 | 2.00 |
| *d* 10.50 | 3.83 | 6.00 | 6.00 | 3.83 | 2.00 |
| *d* 11.00 | 3.75 | 6.00 | 6.00 | 4.00 | 2.00 |

*a* From Alturas Lake, Idaho.
*b* From Little White Salmon River, Washington.
*c* From Wallowa Lake, Oregon.
*d* From Lake Pend d'Oreille, Idaho.

**almo mykiss clarkii** Richardson. *American Cut-throat Trout.*

merous specimens obtained. Particularly abundant in Lake Washington, Siuslaw River, and the ear its mouth, Wallowa and Alturas lakes, Upper Klamath Lake, and in Des Chutes River. A rison of many specimens indicates that it will be necessary to recognize more species or es of *Salmo* in the northwestern portion of the United States than have hitherto been admitted; seems best to hold the matter open for additional data and consideration.

**26. Salmo gairdneri** Richardson. *Steelhead Trout; "Salmon Trout."*

Seen in large numbers at Astoria and The Dalles. Not common in the Siuslaw, and only 2 specimens obtained in Upper Klamath Lake. While at The Dalles during the last week in September and the first half of October Mr. Alexander examined 4,179 steelheads, of these, 1,531 were males and 2,648 females; 476 males, and 900 females were well developed, and would probably have spawned in four to six weeks. The remaining 2,803, he thinks, would not have spawned until some time in the spring.

*Steelhead salmon taken by Mr. I. H. Taffe, at Celilo, September 18 to 22, 1896, and examined by Mr. Alexander.*

| Date. | Male. | | Female. | | Total. | How caught. | |
|---|---|---|---|---|---|---|---|
| | Number. | Well developed. | Number. | Well developed. | | In wheel. | By spear. |
| Sept. 18, 1896 | 111 | 10 | 124 | 15 | 235 | 160 | 75 |
| Sept. 19, 1896 | 130 | 28 | 110 | 22 | 240 | 180 | 60 |
| Sept. 21, 1896 | 121 | 29 | 366 | 96 | 487 | 192 | 295 |
| Sept. 22, 1896 | 159 | 59 | 391 | 164 | 550 | 350 | 200 |
| | 521 | 126 | 991 | 299 | 1,512 | 882 | 630 |

*Steelhead salmon taken in seines by Mr. F. A. Seufert, at Celilo, September 25 to October 13, 1896.*

| Date. | Male. | | Female. | | Total. |
|---|---|---|---|---|---|
| | Number. | Well developed. | Number. | Well developed. | |
| Sept. 25, 1896 | 129 | 22 | 296 | 103 | 425 |
| Sept. 26, 1896 | 148 | 28 | 281 | 112 | 429 |
| Sept. 27, 1896 | 218 | 91 | 328 | 140 | 546 |
| Sept. 28, 1896 | 97 | 44 | 140 | 48 | 237 |
| Sept. 29, 1896 | 176 | 77 | 234 | 72 | 410 |
| Oct. 5, 1896 | 49 | 12 | 50 | 14 | 99 |
| Oct. 7, 1896 | 116 | 49 | 181 | 60 | 297 |
| Oct. 10, 1896 | 46 | 12 | 81 | 21 | 127 |
| Oct. 13, 1896 | 31 | 15 | 66 | 31 | 97 |
| | 1,010 | 350 | 1,657 | 601 | 2,667 |

Mr. Alexander states that not many steelhead are seen about Seattle until the latter part of November or early in December, or about two months after they begin running up the rivers at the northern end of the sound. During the early part of January, 1897, a good many were taken near Seattle. They were considered equal in quality to those taken in other parts of the sound. Their eggs were in various stages of development; a few fish were spent, but the majority were well advanced and would have spawned in a short time.

**27. Hypomesus pretiosus** (Girard).

Nineteen specimens from Siuslaw River at Florence, where it is abundant about the cannery wharf during the canning season.

**28. Gasterosteus cataphractus** (Pallas). *Alaska Stickleback.*

Found in Siuslaw River at Florence and at mouth of the outlet of Tsiltcoos Lake. Only a few specimens were obtained.

**29. Gasterosteus williamsoni microcephalus** (Girard). *California Stickleback.*

Many specimens from Tsiltcoos Lake, in which it is quite abundant. A few specimens were obtained in Lake Washington by Mr. Alexander, where it was also obtained in 1892.

**30. Siphostoma griseolineatum** (Ayres). *Pipefish.*

One specimen, 10⅝ inches in length, from the Siuslaw River near Point Terrace. It was caught in a 7-inch-mesh salmon gill net.

**31. Ammodytes personatus** Girard. *Sand Lance.*

One specimen, 3⅜ inches in length, from the Siuslaw River at Florence. Dorsal 60; anal 26.

**32. Cymatogaster aggregatus** Gibbons.

Very abundant in Siuslaw River about the cannery wharf during the canning season.

**33. Cottus asper** Richardson. *Prickly Bullhead.*

Nine small specimens collected in Lake Washington, June 15. Head nearly or quite naked, but entire body except belly uniformly covered with small prickles.

**34. Cottus gulosus** (Girard)

A *Cottus* which we with some hesitation refer to this species is very abundant in fresh and brackish waters in Siuslaw River and in the lakes south of Florence, and easily caught on a trawl, or with hook and line. Mapleton, Oregon, Siuslaw River, 25 specimens; Acme, Oregon, South Slough, 4; Whoahink Lake, 3; Tsiltcoos Lake, 20; Tahkenitch Lake, 9; Lake Washington, 1; Lake Sammamish, 2.

**35. Cottus punctulatus** (Gill).

One specimen, 2.75 inches long, obtained from the stomach of a bull trout, Alturas Lake, July 16, 1896. Five from Alturas Lake, July 30, 1896.

**36. Cottus princeps** Gilbert.

*Cottus princeps* Gilbert, Bull. U. S. F. C. 1897, 12, with figure.

Eighteen specimens from Pelican Bay, Upper Klamath Lake. Head 3½; depth 5; D. VII or VIII, 20 or 21; A. 16 to 18; eye 5; snout 4; interorbital width 5½. Ventrals 1, 4; lateral line scarcely complete; anterior portion of body covered with prickles; posterior part smooth below. Head rather long, pointed; maxillaries reaching to front of pupil. Color same as in *C. leiopomus*, which it closely resembles, but from which it differs in the more numerous dorsal and anal rays, the shorter snout, somewhat broader interorbital, and in having the body covered with prickles.

**37. Cottus klamathensis** Gilbert.

*Cottus klamathensis* Gilbert, Bull. U. S. F. C. 1897, 10, with figure.

Head 3¼; depth 4¼; eye 3⅝; snout 3½; D. VII, 19; A. 13 or 14; V. 1, 4; interorbital width 5; maxillary reaching front of pupil. No teeth on palatines; a single straight preopercular spine, apparently disappearing in older examples; nostril in distinct tubes; body short, stout; head moderately broad, wedge-shaped anteriorly; caudal peduncle short, compressed, its greatest width 2 in eye, least depth 1 in eye; gill membranes joined to the isthmus, widely separated; body smooth. Color rather light; body with about 10 obscure irregular vertical blotches, but everywhere covered with minnet brown spots, a V-shaped bar at base of caudal; spinous dorsal with a dark blotch on its posterior portion; soft dorsal profusely covered with fine black specks; caudal faintly barred with dark and lighter. A single small example from the lower end of Upper Klamath Lake.

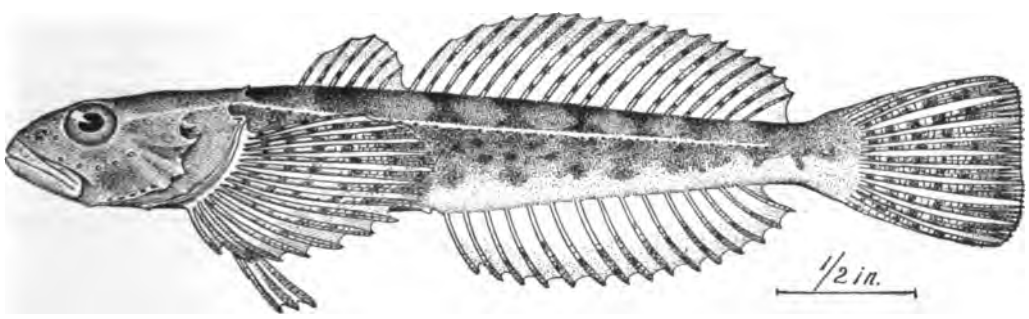



FIG. 6.—*Uranidea tenuis* Evermann & Meek, new species.

**38. Uranidea tenuis**, new species.

Type No. 48229, U. S. N. M.; cotypes No. 5705, L. S. Jr. Univ. Mus., and No. 434, U. S. F. C. Type locality: Lower end of Upper Klamath Lake, near Klamath Falls, Oregon, November 10, 1896. Collectors Meek and Alexander.

Length of type, 3 inches, or 3⅜ inches including caudal. Apparently allied to *Uranidea marginata*.

Head 3¼; depth 7; eye 4½; snout 4; V. 1, 3; D. VI–I, 17; A. 15. Vomer with teeth; palatines toothless. Head long, contracted from eyes forward; snout rather long; body much compressed, very slender; greatest width of caudal peduncle 2½ in eye; least depth of same slightly greater than eye; preopercular spine well developed, broad, rather sharp, partly covered by skin, curved upward; below this two other spines, the anterior one blunt, the other sharp, directed toward lower base of pectoral; post-temporal spine well developed. Body smooth, wholly without prickles or scales; lateral line complete except on caudal peduncle.

Color, dark above and on upper three-fourths of sides, pale below; dorsal fins barred with series of dark dots or blotches; caudal similarly marked but rather darker; anal light with a few dark blotches; pectorals same as caudal; ventrals plain; under side of head profusely covered with small, round black specks; muciferous pores on head well developed.

Besides the specimen described above we have two others of the same slender style from Pelican Bay, and many others from Pelican Bay, the majority of which are much smaller and less slender. The slender ones are apparently entirely smooth; a ripe female 3 inches long has a few prickles on anterior part of body, while all the smaller ones are pretty well covered with small prickles.

**39. Leptocottus armatus** Girard

Very abundant in Siuslaw River below Acme and easily caught on a trawl or with hook and line.

**40. Platichthys stellatus** Pallas. *California Flounder.*

Common about the mouths of Siuslaw River and Ten Mile Creek; occasionally taken during the summer as far up the river as Mapleton. Of 11 specimens from Siuslaw River and Ten Mile Creek, 6 are dextral and 5 are sinistral.

S O U N D

A N

# 3.—THE FISHES FOUND IN THE VICINITY OF WOODS HOLE.

BY HUGH M. SMITH,

*Chief of Division of Scientific Inquiry, U. S. Fish Commission.*

Since the establishment of the United States Commission of Fish and Fisheries in 1871, systematic fish collecting has been carried on at Woods Hole, Massachusetts, by Commission assistants. In the year named, Prof. Spencer F. Baird studied the fish fauna of the region and later published a list of the species then observed which has served as a valuable guide in subsequent investigation.

For more than a quarter of a century almost daily observations, based on collections, have been made and recorded, and it may be safely asserted that nowhere else in the United States has such long-continued and comprehensive work of this character been done. The duty of collecting specimens and recording information has fallen chiefly to the lot of Mr. Vinal N. Edwards, of the Fish Commission, to whose assiduous labors the principal additions to the fish fauna are due.

The collection of specimens has been done chiefly with fine-meshed bag seines, about 150 feet long, hauled from the shore in harbors and coves and on the beaches in Vineyard Sound and Buzzards Bay. This has been supplemented by the setting of fyke nets in suitable localities, by the employment of surface tow nets and dip nets, and by the use of hand lines. The traps or pound nets of the commercial fishermen in Buzzards Bay and Vineyard Sound have also been regularly visited and have yielded many interesting specimens.

Professor Baird's "List of fishes collected at Woods Hole"[1] has remained the only list of the kind. It gives the names of 121 species taken in 1871, two of which have since been shown to be identical, leaving 120 species known from the region at that time. In the twenty-seven years that have since elapsed the list has been augmented almost annually by one or more fishes and has grown to the large proportions here shown.

In the Report of the U. S. Fish Commission for 1882, Dr. Tarleton H. Bean published a "List of fishes collected by the U. S. Fish Commission at Woods Hole, Mass., during the summer of 1881." It mentions about 114 species, but less than half of this number were fishes actually obtained in the vicinity of Woods Hole, the others being deep-sea or offshore fishes, like the tilefish, pole flounder, and hagfish, brought to the station by exploring vessels.

The present list is based on the collections of Woods Hole fishes at the station, in the U. S. National Museum, and at the laboratory of the Fish Commission in Washington, on the yearly records kept by Mr. Edwards, and on personal observations by the writer in 1897.

[1] Report U. S. Fish Commission, 1871–2, pp. 823–827.

Partly on account of the systematic collecting, and partly because of the very favorable geographical position of Woods Hole, an unexpectedly large number of fishes have been ascertained to inhabit the region as permanent residents, regular seasonal migrants, casual visitants, or stragglers. There is probably no other locality in the United States, with the exception of southern Florida, in which so many species have been detected. Excluding the fresh-water fishes, more than 200 species have been obtained at Woods Hole. The section is interesting as marking the northern limit of distribution of many common fishes, and, on the other hand, the southern limit of a number of northern species.

The most striking feature of the fauna is the extent to which species characteristic of the West Indies or Florida are represented. This enrichment of the fauna is directly traceable to the Gulf Stream, which is within about 100 miles of Woods Hole. Most of the southern fishes are very young, the adults of many species being either entirely absent or quite rare; and it is apparent that their presence in the waters of southern New England is involuntary. Falling within the influence of the Gulf Stream, the small fishes are passively carried northward. A common medium of transfer is the gulf-weed or sargasso-weed (*Sargassum bacciferum*), under which the fishes congregate for protection. The patches of floating weed are often of large size, affording ample shelter and at the same time furnishing food to the fishes beneath and among them. Winds from the south, southeast, east, or northeast dislodge the weed from the Gulf Stream and distribute it along the shores of the United States. The configuration of the shore of southern New England forms a kind of huge pocket in which the drift is concentrated, in Buzzards Bay and Vineyard Sound, from a wide expanse of sea. The weed appears in this section every year and is distributed by winds and tides in Buzzards Bay and Vineyard Sound. It is most abundant after southerly winds. The fishes which it shelters gradually become dispersed in the inshore waters as the weed is driven ashore or dies and sinks.

There is every reason to believe that practically all the young fishes which do not get out of the Gulf Stream before it has ascended very far along the east coast of the United States must inevitably perish, since their small size makes their return to southern waters almost impossible. Those which are blown ashore on the Middle and North Atlantic coasts in spring, summer, and early fall doubtless find the surface water not uncongenial, and survive until winter, while those which are carried out of the Gulf Stream in winter must very quickly succumb to the cold. The Gulf Stream is, in fact, a great highway along which a continuous body of fish and other animals, in infinite variety, is being carried from their natural habitat in the south to almost certain destruction in the north.

During July, 1897, there was an unusual prevalence of southerly, southeasterly, and southwesterly winds. Toward the end of the month the weed drifted into Vineyard Sound and Buzzards Bay in large quantities, and was distributed by the tide in long, straggling lines. To this circumstance may be attributed the capture during the subsequent summer and fall months of a number of fishes that were either very rare or wholly unknown in the region heretofore. On July 24, in the course of two hours, 15 species were obtained in gulf-weed off Great Harbor, by means of small dip nets operated from a sailboat. Among these were the marbled angler (*Pterophryne histrio*), Bermuda chub (*Kyphosus sectatrix*), log perch (*Palinurichthys perciformis*), rudder-fish (*Seriola zonata*), dolphin (*Coryphæna hippurus*), trigger-fish (*Balistes vetula*), sobaco

(*Canthidermis asperrimus*), and filefish (*Monacanthus hispidus*). A single piece or mass of gulf-weed was sometimes found to harbor a number of species of fishes.

The information hereafter presented consists of the following parts:

I. Annotated list of fishes known to inhabit the Woods Hole region.

II. Fishes of the Woods Hole region not previously reported so far north or south.

III. Fishes obtained in the Woods Hole region which have not yet been found elsewhere on the United States coasts.

IV. Fishes recorded from adjacent localities which may be looked for near Woods Hole.

V. Fresh-water fishes collected in the vicinity of Woods Hole.

A map is appended covering the region within a radius of about 25 miles of Woods Hole and showing the places referred to in the accompanying lists.

The visits of many biological students annually to Woods Hole and the continuation of systematic collecting by the Commission warrant the expectation of a number of additions to the fish fauna in the next few years. The use of a small purse seine offshore in Vineyard Sound and Buzzards Bay and the employment of a small beam trawl on suitable bottom in the same waters will undoubtedly result in bringing to light fishes new to the region. That there is still something to be learned regarding the fish life of this section may be readily inferred from the outcome of the collections in 1897, when, twenty-six years after systematic work was begun, five species, including one species new to science, were added to the list.

This paper is presented chiefly as a basis for future inquiry; it contains but little information concerning the fishes mentioned, with the exception of a statement of their abundance and the times when they are found. The daily observations that have been made regarding the fishes of the region, supplemented by meteorological data and the very valuable fish-cultural records of the station, afford material for a comprehensive account of the fish fauna which it is hoped will shortly be prepared.

## I.—ANNOTATED LIST OF FISHES KNOWN TO INHABIT THE WOODS HOLE REGION.

In the following list there are arranged in systematic order, by families, all species of fishes known to have been found in the vicinity of Woods Hole. In nomenclature and sequence of species, the "Check List of the Fishes and Fish-like Vertebrates of North and Middle America"[1] has been followed. The local names which the fishes bear in this region are indicated by means of quotation marks. The existence in collections of specimens from this section is for convenience and brevity designated for each species by means of signs; an asterisk (*) referring to the fish collection of the U. S. National Museum in Washington, a dagger (†) to the local museum of the Fish Commission at Woods Hole, and a section mark (§) to the laboratory of the Fish Commission at Washington. The fishes enumerated represent 88 families, 160 genera, and 209 species. The families having a noteworthy number of species are the *Clupeidæ*, 9 species; the *Scombridæ*, 11 species; the *Carangidæ*, 18 species; the *Sciænidæ*, 7 species; and the *Gadidæ*, 9 species.

### PETROMYZONIDÆ. The Lampreys.

**1. Petromyzon marinus** Linnæus. *Great Sea Lamprey; "Lamprey Eel"; "Lamper Eel."* (* †)
Not abundant. Taken in traps in Buzzards Bay in May and June.

### GALEIDÆ. The Requiem Sharks.

**2. Mustelus canis** (Mitchill). *Smooth Dogfish; "Dogfish"; "Switchtail."* (* †)
Very abundant from about June 1 to November. Feeds mostly on crabs. The largest examples are 5 feet long, the usual length being 3 feet.

**3. Galeocerdo tigrinus** Müller & Henle. *Tiger Shark; "Spotted Shark."* (*)
Present every year in variable abundance, and caught in traps in Vineyard Sound and Buzzards Bay. The last species of shark to appear in this region, rarely coming before August. It remains until October. Usual length, 5 feet.

**4. Prionace glauca** (Linnæus). *Great Blue Shark.* (*)
Very rare, apparently only one having been taken; this was obtained from a trap in July, 1877.

**5. Carcharhinus obscurus** (LeSueur). *Dusky Shark; "Shovel-nose."* (* †)
Very common, but less so than the sand shark. Taken in traps and on lines fished from wharves. Comes about June 1 and remains through a part of November. The largest observed here are 12 to 14 feet long; the average are 8 or 9 feet, and the smallest are 2½ feet.

**6. Carcharhinus milberti** (Müller & Henle). *Blue Shark.* (*)
Given by Professor Baird in his 1871 list. Four examples about 4 feet long were taken in a trap at the breakwater, on August 8, 1873, and sent to Washington. None has since been observed. Their color is described by Mr. Edwards as being an intense, almost indigo, blue.

**7. Carcharhinus limbatus** (Müller & Henle). *Spotted-fin Shark.* (*)
Observed on only one occasion. In 1878 at least 20 were taken in traps at the breakwater and Quisset Harbor during a period of three weeks. All were about 4 feet long, and all were found dead in the traps. The "stray specimen taken at Woods Hole, Mass.," referred to in several lists of American fishes, was one of the foregoing lot that was sent to Washington.

### SPHYRNIDÆ. The Hammer-headed Sharks.

**8. Sphyrna zygæna** (Linnæus). *Hammer-headed Shark; "Hammerhead"; "Rakehead."* (* †)
Usually common; some years abundant. Taken in traps from July to October, being most numerous in July and August. Generally swims with its dorsal and caudal fins out of the water. The largest ones taken here are 7 or 8 feet long; the smallest are under 1½ feet, and the average are 4 feet. The name "rakehead" is an old local designation of this species

[1] Report U. S. Fish Commission, 1895.

### ALOPIIDÆ. The Thresher Sharks.

**9. Alopias vulpes** (Gmelin). *Thresher; "Thrasher;" Swingle-tail.* (*)

Common in Vineyard Sound in vicinity of Menemsha; also found in Buzzards Bay. Not infrequently caught in the fish traps. In fall the boat cod fishermen at Gay Head catch them on lines baited with fresh herring. At Woods Hole three "thrashers" 16 feet long were taken one morning in a trap at the breakwater. Specimens 20 feet long have been caught at Menemsha. Some only 4 feet long have been obtained. This species comes in April and remains until late in fall.

### CARCHARIIDÆ. The Sand Sharks.

**10. Carcharias littoralis** (Mitchill). *"Sand Shark."* (* †)

The commonest shark in this region, found from June to November, and often caught with traps and lines. The largest are 12 feet long; the average length is 4½ or 5 feet. Fish, crabs, and various other animals are found in their stomachs.

### LAMNIDÆ. The Mackerel Sharks.

**11. Isurus dekayi** (Gill). *"Mackerel Shark."* (* †)

Quite common in Vineyard Sound and Buzzards Bay. Most numerous in fall, remaining till end of November. Largest 10 feet long; average 4 to 5 feet.

**12. Carcharodon carcharias** (Linnæus). *Man-eater Shark.* (*)

Rare. Reported by Professor Baird in his 1871 list. The U. S. National Museum contains several specimens sent from Woods Hole.

### SQUALIDÆ. The Dog-Fishes.

**13. Squalus acanthias** Linnæus. *Dogfish; "Horned Dogfish."* (* †)

Less abundant than formerly, and comparatively scarce in 1897. When the fish factory was established at Woods Hole, this was the principal fish utilized in the manufacture of oil and guano; later, the scarcity or irregularity of the supply necessitated the use of menhaden. When the horned dogfish first comes, in May, it feeds largely on ctenophores.

### SQUATINIDÆ. The Angel Sharks.

**14. Squatina squatina** (Linnæus). *Angel-fish; Monkfish.* (*)

A specimen weighing 35 or 40 pounds and 3 or 4 feet long was taken in a fish trap at Menemsha Bight, September 1, 1873. It was sent to Washington at the time. The species has not since been observed.

### RAJIDÆ. The Skates.

**15. Raja erinacea** Mitchill. *Summer Skate; "Bonnet Skate."* (* †)

The commonest species of skate in this region. Found from June to October. In allusion to the habit the fish has of rolling itself up when caught, the local fishermen call it the "bonnet skate."

**16. Raja ocellata** Mitchill. *Big Skate; "Winter Skate."* (* †)

Common from February to June and from October 15 to end of trap fishing. Either absent or very rare in summer.

**17. Raja radiata** Donovan. *Starry Ray.* (*) Not common.

**18. Raja eglanteria** Bosc. *Brier Ray.* (* †)

Not common. A few taken every year in traps at Menemsha; formerly caught at the breakwater.

**19. Raja lævis** Mitchill. *"Barndoor Skate."* (* †) Common in spring and fall, rare in summer.

### NARCOBATIDÆ. The Electric Rays.

**20. Tetranarce occidentalis** (Storer). *Torpedo; "Crampfish."* (* †)

Not uncommon in Buzzards Bay and Vineyard Sound from May to November. Most numerous in October and November. At times as many as half a dozen are taken at one lift of a trap at Menemsha. The average weight is 30 pounds, the maximum 75 pounds, and the minimum 4 or 5 pounds.

### DASYATIDÆ. The Stingrays.

**21. Dasyatis centrura** (Mitchill). *"Sting Ray."* (* †)
Common during summer, appearing early in July. The fishermen are much afraid of them.

**22. Pteroplatea maclura** (LeSueur). *Butterfly Ray; "Angel-fish."* (' †)
Rare. Observed mostly in August and September.

### MYLIOBATIDÆ. The Eagle Rays.

**23. Myliobatis freminvillei** LeSueur. *Sharp-headed Ray; "Sting Ray."* (* †)
Not very common. A few are taken every year in traps.

**24. Rhinoptera bonasus** (Mitchill). *Cow-nosed Ray; "Sting Ray."* (* †) Common.

### ACIPENSERIDÆ. The Sturgeons.

**25. Acipenser sturio** Linnæus. *"Sturgeon."* (* †)
Common. Most numerous in Vineyard Sound in June and July. Has the habit of jumping out of the water; at times as many as half a dozen may be seen in the sound at once. There is a considerable catch in traps, many 3 to 4 feet long being taken. The sturgeon was formerly thrown away when caught, but is now sold.

**26. Acipenser brevirostris** LeSueur. *Short-nosed Sturgeon.* (†)
Found in company with common sturgeon, but less numerous than latter. Taken in traps.

### SILURIDÆ. The Cat-Fishes.

**27. Felichthys marinus** (Mitchill). *Sea Catfish; Gaff-topsail Catfish.* (* †)
Quite rare. Reported by Professor Baird in 1871. Recently but few have been seen; one specimen caught in a trap at Menemsha in 1886 is preserved in the collection.

**28. Galeichthys felis** (Linnæus). *Sea Catfish.* (†)
Reported to have been common in spring in Vineyard Sound many years ago, being often taken with cod; now very rare, and only occasionally observed since the Fish Commission station at Woods Hole was established. A specimen was taken in 1887, since which time none has been reported.

### ANGUILLIDÆ. The True Eels.

**29. Anguilla chrysypa** Rafinesque. *"Eel."* (* † §)
Abundant at all times, but most numerous in October. On west side of Buzzards Bay traps have been set especially for eels, and large catches have been made. During two weeks in October, 1893, one trap took 350 barrels; in one night between 30 and 35 barrels were caught.

### LEPTOCEPHALIDÆ. The Conger Eels.

**30. Leptocephalus conger** (Linnæus). *Conger Eel.* (* †)
Comes in July and remains until fall; very common for several years, but rather rare formerly. Fishermen as a rule do not distinguish from the common eel. A few are taken in traps and with lines, but many large ones, weighing from 8 pounds upward, are caught in lobster pots. A specimen in the collection weighs 10 pounds. One caught on a line at Falmouth, August 30, 1897, weighed 12 pounds. The smallest observed are 15 to 20 inches long.

### ELOPIDÆ. The Tarpons.

**31. Tarpon atlanticus** (Cuvier & Valenciennes). *Tarpon.*
Taken every year in traps at South Dartmouth, also occasionally at Quisset and at Menemsha, in latter part of September. All are about one size, 80 to 100 pounds. Fishermen call them "big-scale fish." An effort has been made to find a market for them in New Bedford, but the people did not like them, owing to the toughness of the flesh.

**32. Elops saurus** Linnæus. *Ten-pounder; Big-eyed Herring.* (* †)
Common in fall, none appearing before October. Taken in traps in Vineyard Sound and in herring gill nets at Vineyard Haven. Many have been sent to the Fish Commission by fishermen for identification. Average length, 18 to 20 inches. No young fish observed.

## ALBULIDÆ The Lady-Fishes.

**33. Albula vulpes** (Linnæus). *Lady-fish; Bonefish.* (*)

Very rare. Reported by Professor Baird in 1871, and since observed only once or twice. None seen for many years.

## CLUPEIDÆ. The Herrings.

**34. Etrumeus sadina** (Mitchill). *Round Herring.* (*)

Apparently rare. Known to have been found on only a few occasions. Some years ago, in October, several were taken in traps at Menemsha Bight.

**35. Clupea harengus** Linnæus. *Sea Herring; "Herring"; "Sperling"* (young). (* †)

Schools of large herring, in a spawning condition, appear about October 15 and remain till very cold weather sets in, their departure corresponding with that of cod. By January young herring ¼ inch long are taken in surface tow nets; by May 1 they are 1 to 1½ inches long, and by August 1 they have attained a length of 2½ to 3 inches. Fish 3 to 5 inches long, called "sperling," are found from September 1 to end of season and are used for mackerel bait. About June 1 there is a large run of herring, smaller than those in the fall run. This lasts two weeks, during which the traps are full of them. No use is made of the early run, but in fall they are caught in gill nets for food and bait.

**36. Clupanodon pseudohispanicus** (Poey). *Spanish Sardine.* (* †)

First seen in 1892, when it was abundant throughout the region. It appeared at Menemsha in September and was taken in the traps. A few weeks later it was found in large numbers at Woods Hole, remaining till late in fall. In Eel Pond over 250 were taken at one seine-haul. Since then only a very few have been observed each year, none being taken in 1897. The fish is 4 or 5 inches long and is usually found with young herring (*Clupea harengus*) of slightly smaller size.

**37. Pomolobus mediocris** (Mitchill). *"Hickory Shad."* (* †)

Common. Comes in spring but is most numerous from last of September to end of trap-fishing season. In October, 1895, a trap near Tarpaulin Cove caught 3,500 at one lift. These brought 10 cents each in New York. In spring and summer the fish has no market value, but in fall it is shipped to New York.

**38. Pomolobus pseudoharengus** (Wilson). *Branch Herring; "Alewife"; "River Herring."* (* † §)

Arrives in March and is taken during March and April. By May 1 most of the fish have entered the streams and ponds to spawn; early in May it begins to return to salt water. Many are caught in scoop nets for bait.

**39. Pomolobus æstivalis** (Mitchill). *Glut Herring; "Blackback."* (* † §)

Common. Comes later than branch herring. Spawns in adjacent ponds.

**40. Alosa sapidissima** (Wilson). *"Shad."* (* †)

Comes about May 1 and is taken in traps. Less numerous than formerly; twenty-five years ago probably 100 times as many were caught as in recent years. In 1897 the average number taken in a trap was not over three to five.

**41. Opisthonema oglinum** (LeSueur). *Thread Herring.* (* †)

Very rare. A number were taken in the fall of 1871, but the species is not recorded in Professor Baird's list. In 1885 it was quite common in Buzzards Bay and Vineyard Sound in July. It remained about a month, and specimens were taken in traps at almost every lift. During the next four years the fish was also noticed, but none has been seen since 1890. Recorded from Newport, Rhode Island, from which place the type came; but not regularly found north of the Carolinas.

**42. Brevoortia tyrannus** (Latrobe). *"Menhaden"; "Pogy."* (* † §)

Arrives in schools about May 20, but scattered fish are taken in March with alewives; they remain until first of December, sometimes as late as December 20, but are most abundant in June. When the schools first arrive the reproductive organs of many of the fish are in an advanced stage of development, but after July 1 none with large ovaries are found. Late in fall the fish again have well-developed roes. The smallest fish are about an inch long; these are found in little schools about the shores and wharves as early as July 15. The young are abundant throughout summer and fall. The average length of adult menhaden is 13 or 14 inches; one fish 18 inches long, probably the largest ever observed, was caught here in 1876.

### ENGRAULIDIDÆ. The Anchovies.

**43. Stolephorus brownii** (Gmelin). *Striped Anchovy; "Anchovy."* (* † §)
Abundant. Occasionally rather uncommon. Found from August to late in fall. Much the most numerous species of anchovy.

**44. Stolephorus argyrophanus** (Cuvier & Valenciennes). *"Anchovy."* (* †)
Not uncommon at times. Most numerous in fall, in company with small herring.

**45. Stolephorus mitchilli** (Cuvier & Valenciennes). *"Anchovy."* (* †)
Abundant. Associates with *S. brownii*.

### SALMONIDÆ. The Salmon Family.

**46. Salmo salar** Linnæus. *Salmon.* (* †)
A few are taken every year in traps in Buzzards Bay and Vineyard Sound, generally in May. The usual weight of those caught is 2½ pounds, large fish being rare. As having salmon in one's possession is against Massachusetts law, it is difficult to learn much about the fish from the fishermen.

**47. Salvelinus fontinalis** (Mitchill). *Brook Trout; Speckled Trout.* (†)
Abounds in the fresh waters of the region, and in fall, where communication exists, regularly enters the salt water, remaining through winter. Occasionally taken in fyke nets set in Great Harbor and Little Harbor.

### ARGENTINIDÆ. The Smelts.

**48. Osmerus mordax** (Mitchill). *"Smelt."* (* † §)
Most abundant in March, but common from October to May; a few are found in summer in Eel Pond and Hadley Harbor. Spawns in February and March. Maximum length 14 inches, minimum 2½ inches; fishes of the latter size being seined in Eel Pond.

### SYNODONTIDÆ. The Lizard-Fishes.

**49. Trachinocephalus myops** (Forster). *Ground Spearing.* (* †)
Rare. On September 10, 1892, two specimens, 4 inches and 2½ inches long, respectively, were taken at Nobska Beach, Woods Hole, in a seine. The National Museum contains a specimen obtained at Woods Hole September 3, 1887, and others taken in 1876, 1878, and 1887.

**50. Synodus fœtens** (Linnæus). *Lizard-fish.* († §)
First noted in 1885, since which time a few have been taken nearly every year in September on the beach inside of Nobska Point. Generally 3 or 4 inches long, but a few are 6 inches long.

### MAUROLICIDÆ.

**51. Maurolicus pennanti** (Walbaum). (*)
A specimen of this pelagic species was taken at Woods Hole on January 3, 1884, and is now in the U. S. National Museum. In August, 1879, one was found on the beach near Provincetown, Mass.

### POECILIIDÆ. The Killifishes.

**52. Fundulus majalis** (Walbaum). *Mayfish; Killifish.* (* †)
Common in summer, especially on sandy beaches. Leaves late in fall and is not seen until about April 1, from which time till May it increases in abundance. Spawns in June.

**53. Fundulus heteroclitus** (Linnæus). *Common Killifish; Mummichog.* (* † §)
Most abundant of the mummichogs, and present at all seasons. Found principally in eelgrass. Spawning is chiefly in June, but to some extent in July and August.

**54. Fundulus diaphanus** (LeSueur). *Spring Minnow; Killifish.* (* † §)
Common throughout year. Very abundant in Waquoit Bay and other places having fresh-water tributaries. Rare in Eel Pond. Found in Hadley Harbor, where there are springs.

**55. Lucania parva** (Baird & Girard). *Rainwater-fish.* (†)
First taken in 1884 in Waquoit Bay, 9 or 10 miles east of Woods Hole, on Vineyard Sound. Since then obtained in all brackish ponds between there and the station. In 1897 was found in Eel Pond and Quisset Harbor for first time.

**56. Cyprinodon variegatus** Lacépède. *Short Minnow; Variegated Minnow.* (* †)
Locally abundant in salt-water ponds near Falmouth. A few are found in Woods Hole Harbor. Spawns in June.

### ESOCIDÆ. The Needle-Fishes and Gar-Fishes.

**57. Tylosurus marinus** (Walbaum). *Garfish; Billfish; "Bill Eel."* (* † §)

Common. Fish 2 to 3 feet long arrive about June 15 and are caught in traps with scup. Young, from 3 to 6 inches long, found along shores and in harbors in summer. Examples 10 to 24 inches long are usually common and often abundant in September and October.

**58. Tylosurus acus** (Lacépède). *Houndfish.* (* †)

A fish of this species, 4¼ feet long, now in the Woods Hole collection, was taken in a trap at the breakwater August 6, 1885; on the top of its head, between the eyes, were 5 or 6 barnacles, each about 2½ inches long. In the Proceedings of the National Museum for 1878, Dr. Goode refers to the capture of this houndfish (then called *Belone latimana*) at Woods Hole in 1875. This specimen was 49 inches long and weighed 5½ pounds. Several other specimens have, from time to time, been sent to Washington from Woods Hole.

**59. Athlennes hians** (Cuvier & Valenciennes). (§)

In the summer of 1895, a specimen of this fish, 2½ feet long, was brought into the Woods Hole market from a trap at the breakwater. This is the only known occurrence of the species in these waters, or, in fact, north of Florida.

### HEMIRAMPHIDÆ. The Halfbeaks.

**60. Hyporhamphus roberti** (Cuvier & Valenciennes). *Halfbeak; "Skipper."* (* †)

Usually common; often abundant at mouth of Vineyard Sound. Found in July, August, and September. Caught in traps at Menemsha, and has also been seined at West Falmouth, on Buzzards Bay. The usual size of the fish is 8 inches, but specimens as small as 3 inches are taken in the fine-meshed collecting seine. In August the thresher shark may frequently be seen among the schools of halfbeaks near Gay Head; when the sharks are driving the fish and causing them to "skip," the jægers (*Stercorarius*) catch them with great dexterity.

### SCOMBERESOCIDÆ. The Saurles.

**61. Scomberesox saurus** (Walbaum). *Saury; Skipper; Billfish.* (* †)

Very rare. Given by Professor Baird in his 1871 list. Since then observed only a few times. Several specimens now in Washington were taken prior to 1880. On December 4, 1885, one was seined on the beach near Nobska Point. Very abundant on the northern side of Cape Cod late in fall, and hundreds of barrels are sometimes taken there in traps; many also go ashore.

### EXOCŒTIDÆ. The Flying-Fishes.

**62. Exocœtus volitans** Linnæus. *"Flying-fish."* (* †)

Common some years, but usually scarce. Taken in traps in Vineyard Sound, and a few have been caught in Great Harbor. Small fish, from 1½ to 4 inches, are obtained in seines in the harbor in the latter part of September and the first of October. Even the smallest specimens have been observed to "fly" a distance of 10 feet.

### GASTEROSTEIDÆ. The Sticklebacks.

**63. Pygosteus pungitius** (Linnæus). *Nine-spined Stickleback.* (* † §)

Common in Eel Pond, Quisset Harbor, and Hadley Harbor, but rare in open harbors. Present throughout the year.

**64. Gasterosteus bispinosus** Walbaum. *Two-spined Stickleback.* (* † §)

Most common of the sticklebacks, being, perhaps, twenty times as numerous as *Apeltes*. Found throughout the year.

**65. Gasterosteus gladiunculus** Kendall. (§)

A stickleback taken at the surface October 15, 1897, is referable to this species. It may be distinguished from *G. bispinosus* by its greater depth, brighter color, and fewer dorsal and anal rays. Reported as not uncommon at the surface in April and May, but rare at other times.

**66. Apeltes quadracus** (Mitchill). *Four-spined Stickleback.* (* † §)

Very common. Found at all seasons.

### FISTULARIIDÆ. The Cornet-Fishes.

**67. Fistularia tabacaria** Linnæus. *Trumpet-fish.* (* † §)

A few are observed every year, mostly in Buzzards Bay near Quisset; some are taken in Great Harbor; found mostly in September and October. The usual size is 7 or 8 inches, the smallest 4 inches; the largest specimen, about 16 inches long, was caught at the station within the inner basin.

### SYNGNATHIDÆ. The Pipe-Fishes.

**68. Siphostoma fuscum** (Storer). *Pipefish.* (* † §)

The types of this species were obtained at Woods Hole.[1] Very common from about the first of May till December, and probably present throughout the year. Found chiefly among eelgrass. Spawning occurs about June 1. Very young transparent pipefish are sometimes taken at the surface in tow nets in July.

### HIPPOCAMPIDÆ. The Sea-Horses.

**69. Hippocampus hudsonius** DeKay. *Sea-horse.* (†)

Rare. A few are picked up every year in August and September in Vineyard Sound in gulf-weed or rock-weed. All are about 4 inches long.

### ATHERINIDÆ. The Silversides.

**70. Menidia gracilis** (Günther). *Silverside.* († §)

Abundant. Often in large dense bodies about piers in July, August, and September and as late as December. Appears early in spring and remains later than *M. notata.*

**71. Menidia notata** (Mitchill). *Silverside; "Brit."* (* † §)

Very abundant from April to December. In November exceedingly numerous in harbor.

### MUGILIDÆ. The Mullets.

**72. Mugil cephalus** Linnæus. *Striped Mullet; "Jumping Mullet."* (* † §)

Commoner than the white mullet. Found from September to end of October, going in large schools about October 1. Largest, 10 inches; average, 7 or 8 inches.

**73. Mugil curema** Cuvier & Valenciennes. *White Mullet; "Jumping Mullet."* (* †)

Common from July 1 to October. Largest, 5 inches long. In summer fish from ¾ inch to 2 inches long and upward are taken.

**74. Querimana gyrans** Jordan & Gilbert. *Whirligig Mullet.* (§)

Common in summer. Originally described from Key West, this species has been successively recorded from North Carolina, Virginia, and Massachusetts.[2]

### SPHYRÆNIDÆ. The Barracudas.

**75. Sphyræna barracuda** (Walbaum). *Barracuda.* (§)

A rare straggler. First recorded from Woods Hole by Dr. Goode, who says "it occasionally finds its way into our northern waters, and one or two specimens of it and other West Indian species have been taken at Woods Hole."[3] A young example 3¼ inches long was seined at Quisset Harbor September 22, 1897.

**76. Sphyræna guachancho** Cuvier & Valenciennes. *Barracuda.* (*)

A rare straggler not recently met with. A specimen 22 inches long was taken at Woods Hole July 7, 1876. Another was caught in Buzzards Bay, near Woods Hole, July 17, 1883.

**77. Sphyræna borealis** DeKay. *Barracuda.* (* † §)

Dr. Goode[3] said of this fish in 1882 that it had "recently appeared in considerable numbers on the coast of southern Massachusetts. * * * No specimens of greater length than 10 or 12 inches have ever been taken, and individuals of this size are very unusual, though smaller ones, ranging from 2 to 6 inches, are occasionally found in large schools about the western end of Marthas Vineyard

[1] See Storer, Rept. Mass. Fishes, 1838. [2] See Bull. U. S. F. C. 1894, p. 20. [3] Nat. Hist. Aquat. Anim., p. 448.

and about Wood's Holl, Massachusetts. It seems incredible that the young should occur so abundantly in these waters and the full-grown individuals should be absent. This is possibly because we do not yet know how to capture them."

Specimens 2 to 6 inches long are common in this region after July, but large fish are rare. Most numerous at Woods Hole from October 1 to December, although at Gay Head many occur as early as July and many are caught in fish traps in fall. When snow falls early, large numbers sometimes come ashore dead in Buzzards Bay and Vineyard Sound. Examples 18 inches long are sometimes taken, but those 12 inches long are uncommon and the usual length of the larger fish is only 8 inches.

### POLYNEMIDÆ. The Threadfins.

**78. Polydactylus octonemus** (Girard). *Eight-threaded Threadfish.*

A specimen 4 inches long was taken in a seine in Little Harbor in September, 1882. The identification was by Professor Baird (as *Trichidion octofiliis*). The fish was sent to Washington at the time, and appears on the fish register of the National Museum, but seems to have been lost.

### AMMODYTIDÆ. The Sand Launces.

**79. Ammodytes americanus** DeKay. *Sand Launce; Lant; "Sand Eel."* (* † §)

Found throughout the year, although most abundant late in fall and early in spring. Only a few are observed in winter, and ordinarily they are not especially common in summer, but some years (1897, for instance) they are fairly plentiful; they usually frequent sandy beaches and rips, and go in dense schools. In this region the launce is rather small, rarely exceeding 6 inches in length, but on the north side of Cape Cod the size is usually 8 inches. This fish is one of the principal foods of the mackerel in this section. Although it burrows in the sand with great rapidity, it is readily caught by the mackerel.

**80. Ammodytes dubius** Reinhardt. *Sand Launce.* (*)

Apparently very rare on the south side of Cape Cod and known to have been taken there on only one occasion (June, 1877), but regularly found north of the cape.

### MULLIDÆ. The Surmullets.

**81. Mullus auratus** Jordan & Gilbert. *Goatfish.* (* †)

Rare. Taken every year in September, mostly in Quisset Harbor. Usually not more than 4 to 6 are obtained annually. Prior to ten years ago the fish was rather more numerous than now, the National Museum containing a good many specimens taken between 1875 and 1880.

### SCOMBRIDÆ. The Mackerels.

Of the richness of the Woods Hole fish fauna the representation of this family is an illustration. Of the 15 species of *Scombridæ* known to inhabit the waters of North and Middle America, 11 have been obtained at Woods Hole.

**82. Scomber scombrus** Linnæus. *Common Mackerel.* (* † §)

This region has felt the general scarcity of mackerel, which has now (1897) existed for more than ten years. Nevertheless, a good many small and medium-sized mackerel have recently been taken in Vineyard Sound, and some years there has been a run of large fish. There is a regular mackerel line fishery carried on with catboats in Vineyard Sound near Gayhead, and the fish is also taken in traps at Menemsha and in Buzzards Bay. The mackerel appears in the latter part of May or about June 1 and remains for about two weeks; it then disappears for about two weeks, when it is thought to be spawning. About July 4 the fishermen look for its reappearance, after which it remains until the latter part of November.

**83. Scomber colias** Gmelin. *Chub Mackerel; "Bull's-eye Mackerel."* (* †)

Some years abundant in Vineyard Sound and lower part of Buzzards Bay; other years uncommon. Caught in traps and also on lines while fishing for common mackerel. Usually appear about July 15 and leave late in October.

**84. Auxis thazard** (Lacépède). *Frigate Mackerel; "Bonito"; "Tunny."* (†)

Very rare. First observed in 1885, when one was taken in a trap at Menemsha Bight. Since then only one has been recorded; this was caught in a pound net at Woods Hole, June 29, 1892. These weighed respectively 3½ and 3 pounds.

**85. Gymnosarda pelamis** (Linnæus). *Oceanic Bonito; "Blue Bonito."* (*)

This fish has been reported in the Woods Hole region on only one occasion, in 1878, when there was a remarkable run in the traps at Menemsha. The fish remained in the vicinity several weeks, and were caught daily in some of the nets. As many as 2,000 or 3,000 in all were taken. The name "blue bonito" was given them by the fishermen in allusion to the intense dark blue of the back. They were about the same length as the common bonito, but were somewhat heavier. The species was first taken on the United States coast in July, 1877, when a specimen was obtained at Provincetown, Mass.

**86. Gymnosarda alleterata** (Rafinesque). *Little Tunny; "Tunny"; Bonito.* (*)

Usually abundant in Vineyard Sound in July and August. Taken only at Menemsha, where sometimes as many as 100 are caught in a net at one lift. All are of one size, weighing about 8 pounds. The species is stated by Goode[1] to have made its first appearance in American waters in 1871, when several large schools were observed by the Fish Commission in Buzzards Bay and Vineyard Sound.

**87. Thunnus thynnus** (Linnæus). *Horse Mackerel; Tunny.* (*)

Formerly plentiful, but rare for a number of years; none for five years in Buzzards Bay traps. About 1888, one weighing 630 pounds was taken in a trap off Quisset Harbor. Abundant on the north side of Cape Cod.

**88. Germo alalunga** (Gmelin). *Long-finned Albacore.*

On May 21, 1895, a specimen 3 feet long and weighing 21 pounds became entangled in the leader of a fyke net set in Great Harbor and was thus caught. This appears to be the only known occurrence of the fish on the Atlantic coast of the United States, although it is found in the eastern Atlantic and Mediterranean, as well as in the Pacific.

**89. Sarda sarda** (Bloch). *"Bonito."* (* †)

Usually common. Some years abundant and some quite scarce. In traps, at Menemsha, as many as 1,000 are often taken daily in August, September, and first part of October. The average weight is 3¼ to 4 pounds; a few weigh 7 or 8 pounds, and many small ones are caught weighing only half a pound. Very young fish are rare. On one occasion some 2 inches long were taken in July at Menemsha.

**90. Scomberomorus maculatus** (Mitchill). *"Spanish Mackerel."* (* †)

Rare during recent years, and apparently scarcer each season. Formerly abundant. In 1883 or 1884 530 were taken at one lift of a trap at the breakwater. When the fish was abundant it was more common in Buzzards Bay than in Vineyard Sound. Only one or two have of late been taken annually. The average weight in this region is 2½ pounds.

**91. Scomberomorus cavalla** (Cuvier). *"Cero."* (* †)

Appears in Vineyard Sound about July 1, and is quite common until the end of the trap-fishing season. It is much more common than the Spanish mackerel. At times 8 or 10 are taken at one lift of a trap at Menemsha. When traps were set in Buzzards Bay about 35 or 40 of this and the preceding species were caught annually at Quisset. The fishermen do not distinguish *S. cavalla* from *S. regalis*, but call both "cero."

**92. Scomberomorus regalis** (Bloch). *Kingfish; "Cero."* (* †)

Occurs in about same abundance and at same time as the foregoing species.

### TRICHIURIDÆ. The Cutlas-Fishes.

**93. Trichiurus lepturus** Linnæus. *Cutlas-fish; Scabbard-fish.* (*)

A specimen 3 feet long was taken at Woods Hole in 1874. A few stragglers have been taken in traps at Menemsha Bight during the last ten years, usually not more than one or two in a season; one that has been preserved was caught September 21, 1874. Chesapeake Bay appears to be the normal northern limit of its range, and is the limit assigned in recent lists. As early as 1840, however, the fish was taken in Buzzards Bay, and in 1845 was recorded from Wellfleet.[2]

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[1] Natural History of Aquatic Animals. [2] See Storer, History of Massachusetts Fishes.

### ISTIOPHORIDÆ. The Sail-Fishes.

**94. Istiophorus nigricans** (Lacépède). *Sailfish.* (*)

Rare. Taken only at Quisset Harbor, where during the past 25 years about half a dozen have been caught in a trap; all were about 9 feet long.

**95. Tetrapterus imperator** (Bloch & Schneider). *Spearfish.* (*)

Generally rare, but between 1885 and 1890 numbers were taken in the traps in Vineyard Sound and Buzzards Bay during July and August. Most were caught in the trap farthest up Buzzards Bay at Quisset Harbor.

### XIPHIIDÆ. The Sword-Fishes.

**96. Xiphias gladius** Linnæus. *"Swordfish."* (*)

Abundant near Gayhead. Rare now in Vineyard Sound, but some time ago a number were taken there annually near Tarpaulin Cove.

### CARANGIDÆ. The Pompanos, Crevallés, Amber-Fishes, Etc.

**97. Oligoplites saurus** (Bloch & Schneider). *Leather-jacket.* (*)

Very rare. Only three instances of its occurrence known. In 1874 one specimen was caught in a trap at Menemsha; on August 13, 1875, another was taken, and in September, 1886, two or three specimens were taken in a pound net at the breakwater. Specimen in the Woods Hole collection, from Newport, Rhode Island, taken September 10, 1886.

**98. Naucrates ductor** (Linnæus). *"Pilot-fish."*

Recorded by Professor Baird in 1871. Not common in inshore waters. The banded rudder-fish (*Seriola zonata*) is usually mistaken for this species by the fishermen.

**99. Seriola zonata** (Mitchill). *Shark-pilot; Rudder-fish; "Pilot-fish."* (* † §)

Common from July to October. Usually seen around spiles, pound-net stakes, vessels, and under floating seaweed. In July and August, 1897, was often met with in Vineyard Sound, under gulf-weed and eelgrass; also in Eel Pond, Great Harbor, Quisset Harbor, Hadley Harbor, and elsewhere. While the *Grampus* was moored at the Woods Hole pier in August, 1897, there was a school of "pilot-fish," 6 to 7 inches long, beneath the bow and stern for several weeks, feeding chiefly on *Menidia gracilis*. They were very shy and would not take the hook, but some were caught with a dip net. This species is not distinguished by fishermen from *Naucrates ductor*. Examples as small as 1¼ inches in length are taken in summer.

**100. Seriola lalandi** Cuvier & Valenciennes. *Amber-fish.* (* † §)

Rare. An amber-fish, 2¼ feet long, taken at Woods Hole September 10, 1895, is apparently referable to this species. Another, 3 feet 1 inch long, taken July 8, 1892, and several others, obtained at various times, have been preserved.

**101. Seriola dumerili** (Risso). *Amber-fish; Amber-jack.* († §)

Rare. The Woods Hole collection contains three specimens, from 7¼ to 13 inches long, taken in August and September.[1]

**102. Decapterus punctatus** (Agassiz). *Round Robin; Scad; Cigar-fish.* (* †)

Reported by Professor Baird in 1871. Recently very rare and observed only in Quisset Harbor; taken there in 1886 and on only one or two other occasions.

**103. Decapterus macarellus** (Cuvier & Valenciennes). *Mackerel Scad.* (* †)

Common every year in fall, but not observed at other times. Comes in October and remains about a month. In Great Harbor several hundred have been taken at one seine-haul. No full-grown fish ever observed. Those taken are usually 5 inches long, none over 6 inches. In October, 1897, the fish was remarkably abundant in Vineyard Sound, some traps taking 10 barrels daily.

**104. Trachurops crumenophthalmus** (Bloch). *Goggler; Big-eyed Scad.* (* †)

Common every year in fall, from about October 15 to November 15. All are 4 to 6 inches long.

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[1] See Rept. U. S. F. C. 1896, p. 172.

**105. Caranx bartholomæi** Cuvier & Valenciennes. *Yellow-jack.* (* † §)

Very rare, but has been obtained during four different years. Nine specimens about 6 inches long were taken in 1876; one 5¼ inches long was obtained November 10, 1885; another was caught in Great Harbor September 30 of the same year; one 2½ inches long was seined August 10, 1886. On October 6, 1897, one 4⅞ inches long was caught in a fyke net in Great Harbor.

**106. Caranx hippos** (Linnæus). *"Crevallé"; Jack.* (* †)

Common. First appear about July 1, and caught as long as the fish traps are set, being most numerous in October. No spawn found in them. Young an inch long are taken about July 1. Large examples occur in fall; they sometimes measure over 2 feet in length and weigh 12 to 14 pounds.

**107. Caranx crysos** (Mitchill). *"Yellow Crevallé"; Hardtail; Runner; Jurel.* (* †)

Arrives and departs about same time as foregoing. Young, 2 to 2½ inches long, are caught in Buzzards Bay in summer. The largest are about 15 inches long and weigh 2 to 3 pounds.

**108. Alectis ciliaris** (Bloch). *Cobbler-fish; Threadfish.* (* † §)

Usually not common, but some years numerous. Found from June 15 until November 1, or later; taken in traps. Three to 8 inches long.

**109. Vomer setipinnis** (Mitchill). *Horsefish; "Dollar-fish."* (* †)

Common some years, rare others, in Buzzards Bay and Vineyard Sound. Usually more numerous than *Selene vomer*. It first appears in August and is found during that month and September.

**110. Selene vomer** (Linnæus). *Lookdown; "Dollar-fish."* (* †)

Rare. A few are taken each year in traps and with the collecting seine, usually in September. First noticed here in 1885.

**111. Trachinotus falcatus** (Linnæus). *Round Pompano.* († §)

Young very common; adults never observed. Fish half an inch to an inch long appear in July; by September 15, when they disappear, they are about 2 inches long.

**112. Trachinotus goodei** Jordan & Evermann. *Permit; Black-finned Pompano.* († §)

Rare, and not observed every year. First obtained in 1894, when about a dozen specimens were seined on Nobska Beach, on September 18. In September, 1897, a number were caught at various places, in company with *T. carolinus* and *T. falcatus*. The specimens are all small—3 inches or less in length.

**113. Trachinotus argenteus** Cuvier & Valenciennes. *Silvery Pompano.*

Rare. On September 7, 1885, a specimen was taken at Woods Hole which was identified by Professor Baird as this species.

**114. Trachinotus carolinus** (Linnæus). *Common Pompano.* (* † §)

Adult fish rare, none having been observed for ten years. Young, from 2 to 4 inches long, common, usually appearing between July 20 and August 1, and remaining till about end of September.

## POMATOMIDÆ. The Blue-Fishes.

**115. Pomatomus saltatrix** (Linnæus). *"Bluefish."* (* † §)

Common. Arrives about June 1 and remains till some time in November, being taken as late as the traps are operated. Most numerous in July and October. Young first appear early in July, being about 3 inches long. Fish from 3 to 6 inches long are often very abundant in the harbors, several hundred being taken at one haul of the collecting seine. Many of this size are caught with lines off the Fish Commission wharves. The largest are taken in fall; some weigh 14 to 16 pounds. Well-developed spawn is found in a small proportion of the bluefish when they first arrive, and at Nantucket large roes have been found as late as July 15.

## RACHYCENTRIDÆ. The Sergeant-fishes.

**116. Rachycentron canadum** (Linnæus). *Cobia; Crab-eater.*

Rare. Not observed every year. All specimens recorded in this region have been taken in September in Buzzards Bay traps and have weighed 5 or 6 pounds. The fish appears to have been more common in the seventies than at present.

### NOMEIDÆ. The Nomeids.

**117. Nomeus gronovii** (Gmelin). *Portuguese Man-of-war-fish.* (* †)

First noticed in 1889, when specimens were taken in Vineyard Sound, on July 6, July 23, and August 12. Since then observed only in 1894, when there were many "Portuguese men-of-war" in Vineyard Sound. For several days in July there were often several dozen of the "men-of-war" in sight at one time off Tarpaulin Cove, and under these the fish were numerous. Sometimes a dozen would be found under one "man-of-war," and 21 were collected by the Commission on July 31, all about 6 inches long.

### CORYPHÆNIDÆ. The Dolphins.

**118. Coryphæna hippurus** Linnæus. *"Dolphin."* (* †)

Large specimens are very rare in Vineyard Sound, and none has been seen since about 1890. In past years some 3 feet long have been taken in traps at Menemsha. Young fish from 2 to 12 inches long are obtained nearly every year in the floating gulf-weed; four or five were secured in 1897 in Vineyard Sound, in July and August.

### CENTROLOPHIDÆ. The Rudder-Fishes.

**119. Centrolophus niger** (Gmelin). *Blackfish; Black Ruff.* (*)

A specimen of this southern European species was taken at Dennis, Mass., about 25 miles east of Woods Hole, on November 23, 1888.

**120. Palinurichthys perciformis** (Mitchill). *"Rudder-fish"; "Polefish."* (* † §)

Common from last of June to October. Observed in gulf-weed and other floating objects. As many as a hundred small and medium-sized fish may sometimes be found under a box, barrel, or tub. It is often seen around pound-net poles and has received the name of "polefish" among the local fishermen. The largest specimens are taken in traps at Menemsha, and are 15 or 16 inches long.

### STROMATEIDÆ. The Butter-Fishes.

**121. Rhombus paru** (Linnæus). *Harvest-fish; "Long-finned Butter-fish."* (†)

Usually rare, but occasionally common. As a rule only 3 or 4 are taken in a season, but one year 300 or 400 were obtained. Observed mostly in June and July, in company with butter-fish.

**122. Rhombus triacanthus** (Peck). *"Butter-fish."* (* † §)

Abundant. There is a noteworthy run in June, mixed with the scup. In 1896 and 1897, as many as 60 barrels were taken from a trap at Naushon at one lift; 30 barrels shipped from this trap to New York in 1897 yielded the fishermen only two 2-cent stamps! This run lasts only 1 or 2 weeks, but the fish is taken from early summer to late fall. Spawning occurs in June. The butter-fish is often seen swimming under jelly-fish.

### TETRAGONURIDÆ. The Square-Tails.

**123. Tetragonurus cuvieri** Risso. *Square-tail; Sea-raven.* (*)

One specimen obtained at Woods Hole November 10, 1890.

### SERRANIDÆ. The Sea Basses.

**124. Roccus lineatus** (Bloch). *"Striped Bass"; Rockfish.* (* †)

Not common. Arrives about May 1, and leaves about November 1. Most numerous in June. Apparently does not spawn in this section. Smallest weigh half a pound; largest 65 pounds.

**125. Morone americana** (Gmelin). *"White Perch."* (* † §)

Abundant in fresh-water ponds of the region connected with salt water. Spawns in ponds in May and June. In October specimens from 8 to 15 inches long are taken in nets in Buzzards Bay and Vineyard Sound.

**126. Epinephelus niveatus** (Cuvier & Valenciennes). *Snowy Grouper.* († §)

Not rare. First reported in 1895, when as many as 10 or 12 specimens were obtained in the Woods Hole region.[1] In 1897 several others were taken in summer and fall; one was caught August 7 in a dredge in Vineyard Sound in 6 fathoms of water and in November several were taken in a fyke net in Great Harbor. All have been of small size (3 inches or less), and most of them have been brought up in lobster pots. A number have also been secured in Rhode Island waters.

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[1] See Rept. U. S. F. C. 1894, p. 171.

**127. Centropristes striatus** (Linnæus). *"Sea Bass"; "Black Bass."* (* † §)

Very common. Arrives in May, and departs from the inshore waters about October 1, being most abundant July to September. Spawns in June. Young are first seen about August 1. Maximum weight 6 pounds. A very important and excellent food-fish, taken in large numbers on lines for market and sport.

### LOBOTIDÆ. The Triple-Tails.

**128. Lobotes surinamensis** (Bloch). *Flasher; Triple-tail.* (* †)

Very rare. Given by Professor Baird in his 1871 list. Since then the fish has been met with on only a few occasions. Specimens now preserved in Washington were taken in August, 1873, and December, 1875. On September 20, 1886, a specimen 2 feet long was taken in a trap at Menemsha, and in August, 1890, another thus caught was sent to Washington.

### PRIACANTHIDÆ. Catalufas.

**129. Priacanthus arenatus** Cuvier & Valenciennes. *Catalufa; Short Big-eye.* (* †)

Rare. First taken in 1876, when 7 specimens were obtained in September and October, after which time for several years 3 or 4 were caught annually. The last specimen, 3¼ inches long, was taken October 2, 1888, in a seine at Quisset Harbor.

**130. Pseudopriacanthus altus** (Gill). *Big-eye.* (* †)

Rare. The local collection contains 2 specimens, 1¼ inches long, taken November 28, 1885. Examples in the National Museum were obtained September 29, 1875, and September 26, 1877. There have been several other known occurrences of the fish in this section; it is also recorded from Marblehead, Mass., by Storer (Fishes of Massachusetts, 1867). On November 1, 1890, a specimen was taken in the Acushnet River at New Bedford. The type of the species was from Narragansett Bay, R. I.

### LUTIANIDÆ. The Snappers.

This family of tropical and subtropical fishes is represented in the Woods Hole collection by an unexpectedly large number of species, some of which were taken for the first time in the fall of 1897. Several large snappers have been taken in traps from time to time, but they can not be identified with certainty, as they were not preserved. On September 28, 1894, a snapper weighing 25 pounds, similar in general appearance to the gray snapper (*Neomænis griseus*), was taken in a trap in Buzzards Bay. It was seen by a number of persons from the Fish Commission station. In 1896 a fish of the same species was caught at Newport.

**131. Neomænis griseus** (Linnæus). *Gray Snapper; Mangrove Snapper.* (§)

Two obtained in the fall of 1897, one 2½ inches long in Eel Pond, September 21, and one 2 inches long in Great Harbor, September 26. Not previously detected and apparently only a waif.

**132. Neomænis jocu** (Bloch & Schneider). *Dog Snapper.* (§)

Apparently only a straggler. One specimen, 2½ inches long, taken in Eel Pond September 21, 18[illegible]

**133. Neomænis apodus** (Walbaum). *Schoolmaster.* (§)

A rare straggler. The collection contains one specimen, 5¼ inches long, taken at Woods H[illegible] September 20, 1888.

**134. Neomænis aya** (Bloch). *Red Snapper.* (†)

A very rare straggler, taken on only one occasion. On October 10, 1890, a specimen weigh[illegible] 8½ pounds was caught in a trap at Menemsha; this is preserved in the collection at Woods Hole.

**135. Neomænis analis** (Cuvier & Valenciennes). *Mutton-fish.* (* †)

In 1897 two specimens were taken; one 1⅛ inches long in Quisset Harbor, August 14, and one[illegible] inches long in the same locality September 4. Seven specimens of similar size in the Natio[illegible] Museum were taken at Woods Hole in 1876.

### SPARIDÆ. The Porgies.

**136. Stenotomus chrysops** (Linnæus). *"Scup"; Porgy; Scuppaug.* (* † §)

Very common. Appears about May 1 and leaves about October 15 or 20, being most abundant in June and July. Spawning occurs during first part of June, and young ½ inch to ¾ inch long are observed by the middle of July. The largest taken weigh about 3 pounds.

**137. Lagodon rhomboides** (Linnæus). *Sailor's Choice; Pinfish; "Shiny Scup."* (* † §)
Not common. A few are usually taken each season from July to September.

**138. Archosargus probatocephalus** (Walbaum). *Sheepshead.* (* †)
Very uncommon of late, not one having been seen or heard of in Vineyard Sound or Buzzards Bay in past four or five years. Formerly quite common, often being caught while line-fishing for tautog and scup. Maximum weight about 3 pounds; smallest 8 or 9 inches long.

### GERRIDÆ. The Mojarras.

**139. Eucinostomus gula** (Cuvier & Valenciennes). *Irish Pompano.* (* † §)
Usually very uncommon. In 1897, when apparently this fish was more common than in any previous year, 5 specimens were taken at one seine-haul in Quisset Harbor on August 14, 2 in the same locality September 7, and another in Eel Pond on September 23; all of these were 1 to 2 inches long. On October 5 the fish was numerous at Quisset Harbor.

### KYPHOSIDÆ. The Rudder-Fishes.

**140. Kyphosus sectatrix** (Linnæus). *Rudder-fish; Bermuda Chub.* (* † §)
Not rare in summer and fall, occasionally found in spring (April); sometimes taken among gulfweed at surface. Specimens usually small, largest about 6 inches.

### SCIÆNIDÆ. The Drums.

**141. Cynoscion regalis** (Bloch & Schneider). *Weakfish; "Squeteague."* (* †)
Usually abundant. Comes about June 1, and leaves October 1 to 10. This is the principal fish taken in traps in Vineyard Sound, the catch in 1896 being over 400,000 pounds. In July, 1897, a school of several hundred followed young herring into the basins at the Fish Commission station and remained there for several days; many weighing 4 to 5 pounds were taken at night with short lines, baited with herring, rapidly drawn in on the surface after having been thrown out a few yards. Young fish as small as 1½ inches long are taken about July 1 at the head of Buzzards Bay. Spawning occurs about June 1, some of the fish having ripe spawn when they arrive. The average weight is 4 pounds; 8 pounds is usually the maximum weight in a season, but in 1897 a squeteague weighing 14 pounds was obtained at Cuttyhunk.

**142. Larimus fasciatus** Holbrook. *Banded Drum.* (†)
A very rare straggler, taken on only one occasion. On August 13, 1889, a specimen 8 inches long was caught in a trap at the breakwater, Buzzards Bay.

**143. Sciænops ocellatus** (Linnæus). *Red Drum; Channel Bass; Redfish.* (†)
Only one fish of this species is known to have been taken in this region. This was caught in 1894 in a trap in Buzzards Bay at the breakwater. The specimen, now in the Woods Hole collection, is 2 feet 10 inches long and weighs about 14 pounds.

**144. Leiostomus xanthurus** (Lacépède). *Spot; Goody.* (* †)
Common in fall, being observed during whole of October. When water temperature reaches 45° F. the fish leaves. All specimens are about 6 inches long.

**145. Micropogon undulatus** (Linnæus). *Croaker.* (†)
On September 9, 1893, a specimen 15 inches long was taken in a trap at the breakwater in Buzzards Bay. This is the only known occurrence of the fish in this vicinity.

**146. Menticirrhus saxatilis** (Bloch & Schneider). *"Kingfish"; Sea-mink.* (* † §)
Adults full of spawn are common in June; uncommon after July 15. Fish about an inch long appear in the middle of July, and the young are numerous on sandy beaches during the summer and until early part of October, when they leave, having attained a length of 4 or 5 inches. Some of the young are almost entirely black, while others of same size taken at the same time show the color markings of the adults. The maximum weight is about 2 pounds.

**147. Pogonias cromis** (Linnæus). *Drum.* (†)
Very rare. First taken May 7, 1874, and observed only 3 or 4 times since. The recent specimens have been taken in traps at Quisset Harbor, in the latter part of September or early in October. All were of one size, weighing 4½ or 5 pounds.

### LABRIDÆ. The Wrasse-Fishes.

**148. Tautogolabrus adspersus** (Walbaum). *"Cunner"; "Chogset."* (* † §)

Very abundant. Remains in eelgrass in winter and thousands perish from cold every year. Large numbers of cunners of all sizes are found under wharves and around piers in warmer months. Spawning takes place in June. By August 1 the young, an inch long, are observed. In the bays and harbors the maximum weight is about a pound, but outside of Gayhead and Cuttyhunk they reach a weight of 2½ pounds. The usual weight is one-quarter to one-half a pound.

**149. Tautoga onitis** (Linnæus). *"Tautog"; "Blackfish."* (* † §)

Abundant everywhere on rocky bottom, remaining throughout the year. In winter they seek deep water or the eelgrass; many are killed each year by anchor ice. Spawns in June and July. Young appear about 1st of August. Average weight 3 pounds, but 12-pound fish are common, and some weigh 16 pounds. Many are caught on lines by anglers and professional fishermen, and some are also taken in traps in April. Lobster is the most attractive bait. Judging from the behavior of tautog in aquaria, it must be one of the greatest enemies of both large and small lobsters; it readily attacks full-grown lobsters, first biting off their eyes by rapid darts, and then consuming them. The fish continues to bite at the hook until snow falls, usually about November 15 or 20.

### EPHIPPIDÆ. The Angel-Fishes.

**150. Chætodipterus faber** (Broussonet). *Moonfish; Angel-fish; Spadefish.* (* †)

A very rare straggler. First taken in 1889, when one specimen was obtained. Since then only three have been observed. All were caught in traps at Menemsha in August and September. The fish are all of one size, having a length of 16 to 18 inches. Not known to fishermen.

### CHÆTODONTIDÆ. The Butterfly-Fishes.

**151. Chætodon ocellatus** Bloch. *Parche.* (* † §)

A few specimens are taken nearly every year in October and November, when seining in eelgrass. Three is the largest number caught at one haul of the net, and five the largest number in one season.

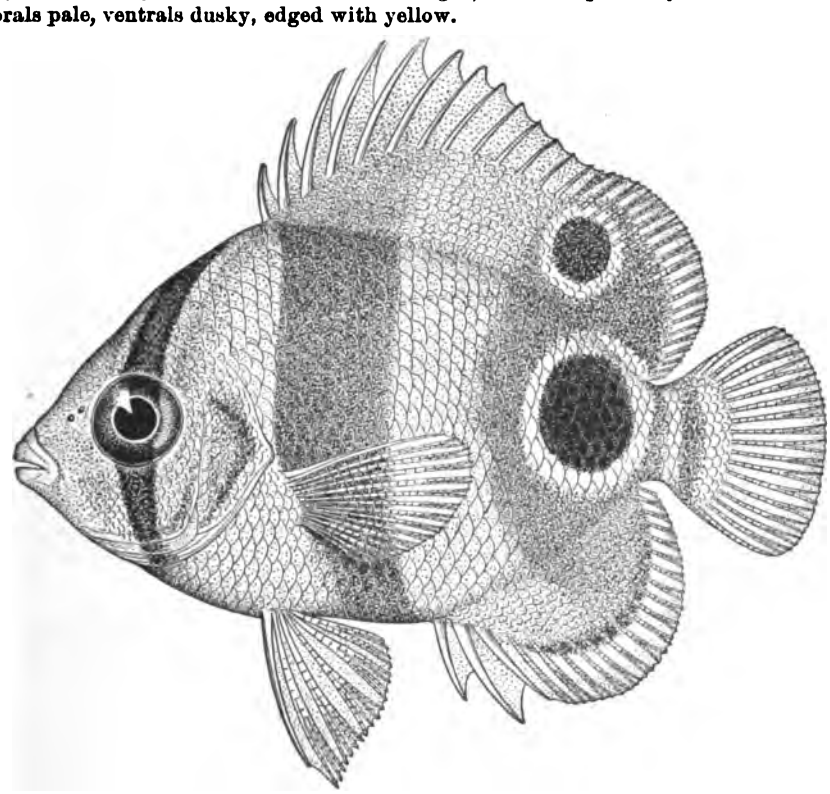
**152. Chætodon bricei**, new species.

Three specimens of an undescribed species of *Chætodon* were seined in the vicinity of Woods Hole in 1897. One was obtained August 3 in Quisset Harbor, another August 10 in Eel Pond, and the third October 7 in Quisset Harbor; all are under 1½ inches in length. These examples were undoubtedly stragglers from the West Indies, whence they were transferred in the Gulf Stream. The species is readily distinguished by two prominent ocelli situated posteriorly, and is one of the most strikingly beautiful members of a large family of peculiarly marked and brilliantly colored fishes of the tropical seas. It is named for Hon. John J. Brice, United States Commissioner of Fish and Fisheries.

*Description.*—Body short, deep, much compressed, its depth contained 1⅓ times in length. Profile steep, slightly convex. Head rather large, pointed, its length rather less than a third of the body length. Mouth small, terminal; snout not produced, five-sixths length of eye. Eye large, its length contained 2⅔ times in head. Lateral line beginning at posterior edge of eye, curving upward and backward, and terminating under anterior part of soft dorsal fin. Scales large; number in median line of body 40; number in transverse series between front of dorsal and base of ventral 23, 6 being above the lateral line; rows of scales above longitudinal axis of body directed upward and backward, those below inclined slightly downward. Caudal peduncle very short, about as broad as eye. Dorsal long, elevated, with 13 spines and 20 rays, the longest spine six-sevenths length of head; soft dorsal evenly rounded; basal half of both portions of fin thickly covered with small scales; dorsal origin opposite posterior edge of opercle. Anal fin deep, long, rounded, containing 3 spines and 18 rays; the proximal two-thirds of soft portion densely squamated, the small scales also covering the bases of the second and third spines. Caudal short, rounded. Pectorals two-thirds length of head, rounded. Ventrals as long as pectorals, pointed.

Colors in life: General body color, pearly gray. A glistening jet black band about two-fifths width of eye, and having a forward curve, begins a short distance in front of dorsal and extends downward through eye and thence downward and backward to lower margin of gill opening; this does not extend on the breast, and hence does not meet its fellow of the opposite side; above eye this stripe is bordered on each side by a very narrow pale streak. A dull blackish band, 1½ times as wide as eye, runs vertically across body from base of dorsal to median line of abdomen; the anterior border

of this band extends from front of dorsal to posterior angle of opercle, thence obliquely downward and backward behind base of pectoral. Behind this band and separated from it by a space somewhat wider than eye is another dark band; it is duller and two-thirds wider than the foregoing, with its anterior edge curved forward and its posterior margin on the caudal peduncle. Involving about two-thirds the width of this band and extending from the dorsal to the ventral edge of the body is a large, circular ocellus, more than 1½ times the size of eye, consisting of a dark-blue spot surrounded by a narrow white zone, which covers a part of the base of the soft dorsal. Immediately above this and within the extension on the dorsal fin of the dark band is another similar but smaller ocellus, about the size of eye, involving the first 8 or 9 rays of the soft dorsal. A narrow, dark-brown, vertical bar on caudal peduncle is separated from the base of the caudal rays and from that part of the broad body band posterior to the ocellus by narrow white spaces. Head in front of ocular stripes, and breast greenish yellow. A black crescentic mark on opercle. Spinous dorsal dusky, the dark vertical band extending on the first 7 spines. Soft dorsal dark, with sharply defined pale edge. Part of anal covered by scales dusky, with a narrow darker margin; unscaled portion yellowish white. Caudal and pectorals pale, ventrals dusky, edged with yellow.



*Chætodon bricei* H. M. Smith.

The foregoing description applies especially to the largest specimen, taken October 7; the others differ from it only in having darker dorsal, anal, and ventral fins, and minor variations in the dorsal and anal rays.

**153. Chætodon striatus** Linnæus. *Portuguese Butterfly.* (§)

Taken on only one occasion. On October 29, 1894, a specimen 1⅞ inches long was caught in a seine in Great Harbor.

## BALISTIDÆ. The Trigger-Fishes.

**154. Balistes vetula** Linnæus. *Trigger-fish; Leather-jacket.* (* † §)

Every season, mostly in September, adult specimens of this fish are taken in some numbers in the traps at Menemsha. During summer and fall the young, 1½ or 2 inches long, are found at the surface in Vineyard Sound in gulf-weed and also around the shores.

**155. Balistes carolinensis** Gmelin. *Trigger-fish; Leather-jacket.* († §)

Very rare; not taken every year. Young not observed.

**156. Canthidermis asperrimus** (Cope). *Sobaco.* (§)

A specimen of *Canthidermis* taken in the summer of 1897 is identified as *Balistes asperrimus* of Cope, the type of which, belonging to the Philadelphia Academy of Natural Sciences, has been examined. The type is 3 inches long and is labeled "Darien" (Isthmus of Panama); no other specimens are known, unless this fish should prove to be the young of Poey's *Balistes sobaco* from the West Indies. The Woods Hole example is 1¼ inches long, and was obtained July 24, 1897, under a small piece of floating gulf-weed in Vineyard Sound off Great Harbor.

## MONACANTHIDÆ. The File-Fishes.

**157. Monacanthus hispidus** (Linnæus). *Foolfish; Filefish.* (* † §)

Present every year; some years rather scarce, some years abundant. In 1897 it was extremely numerous in July and August, and several hundred were often taken in one day in the collecting seine. May often be obtained under gulf-weed, but usually most plentiful in eelgrass and rockweed. No large fish are observed; the maximum size is under 4 inches, and the smallest is 1 inch. The smallest filefish are rather uniformly dull brownish or greenish yellow in color, but those 3 or 4 inches long are mottled with white and several shades of dark green. In aquaria, small filefish often annoy and injure other fish, following them with great persistency and biting their fins, eyes, and other parts. Fish many times larger than themselves are sometimes the object of their attack.

**158. Alutera schœpfii** (Walbaum). *Foolfish; "Filefish."* (* † §)

Rather common every year in August and September. The largest are 18 inches long, the smallest 3 inches. The position constantly assumed in the aquarium is with the head down. Succulent algæ are often eaten by the fish in captivity, the long branches of some species being bitten off and swallowed in a surprisingly short time. The color of the young is a dirty white, with large reddish-brown mottlings or blotches; the larger are orange-colored with same mottlings as when young.

## OSTRACIIDÆ. The Trunk-Fishes.

**159. Lactophrys trigonus** (Linnæus). *Trunkfish; Shellfish.* (* §)

Adult trunkfish have not been observed in this vicinity, but the very young are not uncommon and are taken every year. They are found from July to October. On quiet days they are seen, singly or in scattered bodies, in the eelgrass about the wharves. The largest specimens in the collection are 1 inch long, and the smallest one-fourth inch. They are taken under the gulf-weed, in surface tow nets and in shore seines. Several dozen have been obtained at one seine-haul.

## TETRAODONTIDÆ. The Puffers.

**160. Lagocephalus lævigatus** (Linnæus). *Smooth Puffer; "Puffer."* (* †)

Not very common. Perhaps half a dozen are taken each year in traps in Buzzards Bay and Vineyard Sound, mostly in September and October. All are about 11 or 12 inches long, small ones never being observed.

**161. Spheroides maculatus** (Bloch & Schneider). *Swellfish; "Puffer."* († §)

Appears about first of June, and is abundant during the run of scup; many caught in traps at that time. Common throughout the summer at head of Buzzards Bay, but rare at Woods Hole during that season. Leaves in fall as soon as cold weather sets in. The spawning season is June 1 to 10. The largest are 7 inches in length, but the average size is 5 inches. From about July 1 to October 15 the young, from ¼ inch to 1 inch long, are extremely abundant at Woods Hole, frequenting chiefly sandy beaches, where as many as a hundred are often taken in one seine-haul.

**162. Spheroides spengleri** (Bloch). *Southern Puffer; Swelltoad.* (*)

Very rare. A number of small specimens taken in September and October, 1877; not recently detected.

## DIODONTIDÆ. The Porcupine-Fishes.

**163. Diodon hystrix** Linnæus. *Porcupine-fish.* (§)

A very rare straggler, being taken only once. On August 12, 1895, a specimen, 9½ inches long, was obtained in Buzzards Bay near the station.[1]

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[1] See Rept. U. S. F. C. 1896, p. 173.

**164. Chilomycterus schœpfi** (Walbaum). *Swell-toad; "Puffer"; "Porcupine-fish."* (* †)

Rare, and of irregular occurrence. Some years a few are taken in almost every trap in the vicinity, then none will be caught for several years. The latter part of September and the early part of October are the periods when this fish is observed. The specimens taken are from 2½ to 5 inches long.

### MOLIDÆ. The Head-Fishes.

**165. Mola mola** (Linnæus). *Sunfish.*

Much rarer now than formerly. In the early years of the Commission 8 or 10 specimens were observed annually in Vineyard Sound, but of late there is seldom more than one seen in a season. In 1896 a 400-pound fish was seen off Tarpaulin Cove. In 1887 a 200-pound specimen, caught off Great Harbor, was retained alive at the station for about a week. August is the month when the sunfish is usually found in these waters. A number that have been opened by Mr. Edwards contained only ctenophores and medusæ.

### SCORPÆNIDÆ. The Rock-Fishes.

**166. Sebastes marinus** (Linnæus). *Rosefish; Red Perch; Bream; Norway Haddock.* (* †)

Obtained in the Woods Hole region on only one occasion. On December 20, 1895, in Great Harbor, 7 or 8 specimens, 3 inches long, were found in a hole on a flat, where they had been left by the tide; 4 or 5 of these had been stranded and were dead; the others were alive, and are now preserved in the collection. Taken in deep water as far south as New Jersey, but not previously recorded from inshore waters south of Maine. Fishermen claim that they sometimes catch these fish in traps very late in fall at Provincetown.

### COTTIDÆ. The Sculpins.

**167. Acanthocottus æneus** (Mitchill). *Little Sculpin; Grubby.* (* † §)

Very common. Remains during entire year, and is the only sculpin found during summer. In winter from 10 to 50 are caught daily in fyke nets set in harbor. The fish is then in a spawning condition, and the eggs adhere to the twine. The maximum size of the fish is 5 inches.

**168. Acanthocottus octodecimspinosus** (Mitchill). *Eighteen-spined Sculpin; "Sculpin."* (* †)

First appear about October 1, become very abundant by October 15, and remain until December or January. The spawning time is November and December; the eggs often come ashore by bucketfuls on Nobska Beach.

**169. Acanthocottus grœnlandicus** (Cuvier & Valenciennes). *Daddy Sculpin; "Sculpin."* (* †)

The foregoing remarks apply equally well to this species.

**170. Hemitripterus americanus** (Gmelin). *Sea-raven; "Red Sculpin."* (* †)

Common in October and November. Usual length about 16 inches. Young are rarely seen.

### CYCLOPTERIDÆ. The Lump-Suckers.

**171. Cyclopterus lumpus** Linnæus. *"Lumpfish."* (* † §)

Adults common in April; a few in May. Young are taken throughout the summer in Vineyard Sound among driftweed. Spawning occurs in April.

### LIPARIDIDÆ. The Sea-Snails.

**172. Neoliparis montagui** (Donovan). *Sea-snail.* (*)

Apparently not common in the shallow waters reached by the collecting seine. No specimens in local collection.

**173. Liparis liparis** (Cuvier). *Sea-snail; "Sucker."* (* †)

Common in the winter on rocky bottom. Found full of spawn in December and January.

### GOBIIDÆ. The Gobies.

**174. Gobiosoma bosci** (Lacépède). *Goby.* (* †)

Common in Buzzards Bay. Taken in seine at Quisset Harbor throughout the summer.

### BATRACHOIDIDÆ. The Toad-Fishes.

**175. Opsanus tau** (Linnæus). *"Toadfish"; "Toad-grunter."* (* †)

Common under stones in ponds and harbors. Spawns in June, the eggs being attached to the under side of stones. Maximum weight about a pound.

### XIPHIIDÆ.

**176. Pholis gunnellus** (Linnæus). *Butter-fish; "Rock Eel."* (* †)
Abundant around shores in March and April, but rare at other times. May be taken in Vineyard Sound with a dredge at almost any season at a depth of 4 or 5 fathoms. Largest about 7 or 8 inches. Seined only on gravelly bottom.

### CRYPTACANTHODIDÆ. The Wrymouths.

**177. Cryptacanthodes maculatus** Storer. *Wrymouth; Ghostfish.* (* §)
Very rare. On December 18, 1896, one 18 inches long was caught at Woods Hole in a fyke set in Great Harbor.[1] A specimen in the National Museum from Woods Hole was taken about 1875.

### ANARHICHADIDÆ. The Wolf-Fishes.

**178. Anarhichas lupus** Linnæus. *Wolf-fish; "Catfish."* (†)
Quite rare. Taken in Vineyard Sound late in fall in traps and also on lines fished for cod.

### ZOARCIDÆ.

**179. Zoarces anguillaris** (Peck). *Eel-pout; "Sea Eel."* (* †)
Abundant in fall, off Gay Head and Cuttyhunk; caught while line fishing for cod, on rock bottom, and occasionally late in fall in Vineyard Sound off Great Harbor on lines baited for tautog.

**180. Lycodes reticulatus** Reinhardt. *Eel-pout.* (*)
This northern species has occasionally been taken in southern New England. The National Museum contains specimens obtained by the *Fish Hawk* in Vineyard Sound and Narragansett Bay.

### TRIGLIDÆ. The Gurnards.

**181. Prionotus carolinus** (Linnæus). *Common Gurnard; "Sea-robin."* (* †)
Appears in May or June and remains until October or later. More abundant than *P. strigatus*. Begins to spawn early in June. Young are very common in Waquoit Bay in summer, but are rather rare elsewhere. This species attains only a third of the maximum weight of the striped gurnard.

**182. Prionotus strigatus** (Cuvier & Valenciennes).[1] *Sea-robin; "Red Sculpin."* (* †)
Comes in June, somewhat later than *P. carolinus*. It is then rather abundant, but is less common at other times. Spawns in summer. Young, ¾ inch long and upward, are very common throughout summer; by fall they have reached a length of 4 inches. This species attains a length of 18 inches in the Woods Hole region.

### CEPHALACANTHIDÆ. The Flying Gurnards.

**183. Cephalacanthus volitans** (Linnæus). *Flying-robin; "Flying Gurnard."* (* †)
A few are taken every year late in the fall. They sometimes come ashore in Buzzards Bay and Vineyard Sound benumbed by cold. Not so abundant now as they were prior to ten years ago.

### ECHENEIDIDÆ. The Remoras.

**184. Echeneis naucrates** Linnæus. *Shark Sucker; Remora.* (* †)
Not uncommon. One 1¼ feet long was caught at West Falmouth, July 16, 1897, on a hook baited with fresh clam.

**185. Echeneis naucrateoides** Zuieuw. *Sucker.* (*)
Given by Professor Baird in 1871, and a number taken during next ten years. Not recently detected.

**186. Remora remora** (Linnæus). *Remora.* (* †)
Rare. Reported by Professor Baird in 1871. Specimen in collection taken in July. Usually attached to large sharks.

**187. Remora brachyptera** (Lowe). *Swordfish Sucker.* (*) Rare.

**188. Rhombochirus osteochir** (Cuvier). *Spearfish Remora.* (* †)
Rare. Recorded by Professor Baird in 1871. A specimen was taken August 6, 1886, in a fish-trap at Quisset Harbor.

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[1] See Rept. U. S. F. C. 1896, p. 176.

### MERLUCCIIDÆ. The Hakes.

**189. Merluccius bilinearis** (Mitchill). *Silver Hake; Whiting; "Frostfish."* (* †)

Abundant every fall; some years common in summer. The fish swims close to the shore, and is caught in considerable numbers in Buzzards Bay at night with spears, for home use and sale in New Bedford. The weight of those thus taken is about a pound, but those caught in traps usually weigh 5 or 6 pounds. Young specimens, 2½ to 3 inches long, are seined in fall about Woods Hole.

### GADIDÆ. The Cods.

**190. Pollachius virens** (Linnæus). *"Pollock."* (* †)

Adult fish appear in Vineyard Sound and Great Harbor in May, following the run of cod. They depart when temperature of water reaches 60° or 65°. There is no regular fishing with lines, but many are caught in traps at Menemsha. Fyke nets set in the harbor take pollock 7 or 8 inches long in February and March. In April there is a run of fish 1 to 1½ inches long; by June these have attained a length of 4 inches. The fish leave in June. In fall there is a small run of fish 7 or 8 inches long. Average weight of adults about 10 pounds, the maximum being 14 pounds.

**191. Microgadus tomcod** (Walbaum). *Tomcod; "Frostfish."* (* †)

Abundant in winter, coming about October 1 and remaining till May 1. Spawns in December. Many are caught in fykes and sent to the markets.

**192. Gadus callarias** Linnæus. *"Cod."* (* †)

Appears in Vineyard Sound about April 1 and remains till about May 15, or till the dogfish strike on. When the fish first come they feed chiefly on worms, and are known among the fishermen as the "worm school"; later they feed on herring, lants, and crabs, and are known as the "herring school." After the middle of October the cod come again, but in less numbers than in spring, and remain until the first wintry weather. Young cod are first observed about the 1st of April, when fish about 1 inch long are seined. Most of the young leave by June 15, having attained a length of 3 to 4 inches. No cod are seen between fish of that size and those weighing 1½ to 2 pounds caught in traps in spring. There is now but little line fishing for cod in Vineyard Sound, although there is some off Gay Head.

**193. Melanogrammus æglifinus** (Linnæus). *"Haddock."* (* †)

Not detected in Vineyard Sound or Buzzards Bay, but common 6 or 7 miles off Gay Head and on ocean side of Marthas Vineyard. Reported by Professor Baird in 1871.

**194. Phycis regius** (Walbaum). *Codling; King Hake.* (* †)

Rare. Taken in seine only late in fall. Varies in length from 7 to 12 inches.

**195. Phycis tenuis** (Mitchill). *Squirrel Hake; White Hake; "Hake."* (* †)

Fish weighing 1 to 1½ pounds abundant in October and November. A great many then enter Eel Pond. Young fish, 1 inch long and upward, associate with pollock in spring and are also found throughout the summer in considerable numbers. They are often obtained in summer at the surface, under gulf-weed and eelgrass.

**196. Phycis chuss** (Walbaum). *"Hake."* (* †)

Abundant in May and June and in October and November. They fill the traps and cause fishermen much annoyance, as there is no sale for them. They weigh from 2 to 5 pounds.

**197. Rhinonemus cimbrius** (Linnæus). *Four-bearded Rockling.* (* †)

A rare visitor, found only in winter. Once taken in a fyke net in Great Harbor.

**198. Brosmius brosme** (Müller). *Cusk; "Ling."* (* †)

Formerly not uncommon in Vineyard Sound, and caught with cod in April and May. Very rare for twenty years or more, although a few are still taken in April. Average weight is 5 pounds; maximum, 12 or 13 pounds.

### MACRURIDÆ. The Grenadiers.

**199. Macrourus bairdii** Goode & Bean. *Baird's Grenadier.* (*)

Very rare. Obtained once in Vineyard Sound by the *Fish Hawk* at a depth of 9 fathoms, on August 26, 1882.

## PLEURONECTIDÆ. The Flounders.

**200. Hippoglossus hippoglossus** (Linnæus). *"Halibut."* (*)

Formerly not very uncommon in Vineyard Sound, but now very rare. Last taken about ten years ago, when one weighing about 80 pounds was caught. Between ten and twenty-five years ago, during April, a number of large-sized halibut were taken annually while fishing for cod off Great Harbor and elsewhere in the sound. In 1872 or 1873 Mr. Edwards caught a number weighing 235 or 240 pounds.

**201. Hippoglossoides platessoides** (Fabricius). *Sand-dab; Rough-dab; Rusty Flounder.* (*)

Not common. Found some years in winter in the inshore waters adjacent to Woods Hole; specimens have been taken in February on lines. One year some were caught in a fyke net in Great Harbor.

**202. Paralichthys dentatus** (Linnæus). *Summer Flounder; "Flounder."* (* †)

Found from about May 10 to October 15. More abundant during summer than the flatfish. Frequents sandy bottoms. Average weight, 2½ pounds; maximum, 20 pounds. The largest are taken in the traps.

**203. Paralichthys oblongus** (Mitchill). *Four-spotted Flounder; "Flounder."* (* †)

Common in May and June; scarce at other times. Most abundant about June 1, during the run of scup, when many are caught in traps. Young fish are rarely observed, but in the fall of 1885 or 1886 large numbers, 2 or 3 inches long, were seined. Average length, 12 inches. The fish spawns in May and its eggs have been experimentally hatched at Woods Hole. The eggs are buoyant, $\frac{1}{16}$ of an inch in diameter, and hatch in 8 days in water having a mean temperature of 51° to 56° F.

**204. Bothus maculatus** (Mitchill). *"Sand-dab"; "Window-pane."* (* †)

Found from April to late in autumn. There is quite a large run about June 1, when the fish is with spawn. The average size is 10 or 12 inches. In the experimental hatching of the eggs of this fish at Woods Hole it has been found that the eggs are buoyant, nonadhesive, and $\frac{1}{14}$ of an inch in diameter, and that they hatch in eight days when the mean water temperature is 51° to 56° F.

**205. Limanda ferruginea** (Storer). *"Rusty Flatfish."* (* †)

Very common in Vineyard Sound and Buzzards Bay, in water 10 to 12 fathoms deep, where it may be found throughout the year. There is no fishery, but numbers are caught incidentally while bottom fishing for other species. In Great Harbor a few are taken in fyke nets only in winter. The average length is about 14 inches.

**206. Pseudopleuronectes americanus** (Walbaum). *"Flatfish"; "Winter Flounder"; "Pug."* (* †)

A very abundant permanent resident. Frequents muddy or grassy bottom. Some are either wholly or partly blackish on the nude side, this condition being more prevalent some winters than others. The average weight of those taken in the immediate vicinity of the station is only 1 pound, but larger examples are found in the deeper water of the sound and bay. In October fish averaging 2 pounds, and apparently slowly migrating, are taken with lines in Vineyard Sound on sandy bottom; these are called "pugs" by the fishermen, and the fishery is called "pugging."

This fish spawns from February to April in this region and its artificial cultivation is extensively carried on. Spawning fish are very abundant and are caught with fyke nets on hard clay bottom in water 6 to 15 feet deep. On being transferred to tanks containing running water, many deposit their eggs voluntarily during the night. The eggs are $\frac{1}{30}$ of an inch in diameter, and when first extruded are very glutinous, sticking together in masses of various sizes. The average number of eggs to a fish is 500,000. On March 6, 1897, 1,462,000 eggs, or 30 fluid ounces, were taken from a fish that weighed 3½ pounds after spawning. The eggs hatch in 17 or 18 days when the mean water temperature is 37° or 38° F.

## SOLEIDÆ. The Soles.

**207. Achirus fasciatus** Lacépède. *Sole; Hog-choker; "Black Flatfish."* (* †)

A few are taken every year in the traps in Vineyard Sound. It is abundant in Wareham River, at the head of Buzzards Bay; some are found in Waquoit Bay and a few are taken in Great Harbor. It is present throughout the year. In allusion to the dark underparts the fishermen call it the "black flatfish."

### LOPHIIDÆ. The Fishing-Frogs.

**208. Lophius piscatorius** Linnæus. *Goosefish; Angler; Fishing-frog; "Toadfish."* (* †)

Abundant in Vineyard Sound, usually from April 1 to July 1, some seasons from April to November or as late as the traps are set. The spawn is often found floating in Vineyard Sound. The traps often take boatloads of them which are carried ashore and put on the land, no other use being made of them, although the flesh is considered very palatable. Those caught in traps are from 4 inches to 4 feet long. The young keep offshore in deep water and are never taken in the seine.

### ANTENNARIIDÆ.

**209. Pterophryne histrio** (Linnæus). *Marbled Angler.* (* † §)

This fish is to be regarded as a straggler from the tropics, whence it comes in the Gulf Stream and is drifted ashore in gulf-weed. It was first taken in 1877.[1] In November, 1885, 12 specimens were seined in Quisset Harbor. From that year until 1897 none was observed, although the gulf-weed was systematically examined. In 1897 this fish was comparatively common in Vineyard Sound. During July there was an unusual prevalence of southerly winds and a large quantity of sargasso-weed was blown inshore from the Gulf Stream, and with it the marbled angler. During the forenoon of July 24, 22 specimens were taken in a boat from the Fish Commission station with small dip nets, among the gulf-weed in Vineyard Sound, a few miles from Woods Hole, and on the same day 28 specimens were secured by a steamer of the Marine Biological Association. Stragglers continued to be caught during July and August, one being obtained at the Fish Commission wharf on August 2. Probably not less than 100 specimens were taken during the season. Many were kept alive in aquaria for several weeks, and proved of great attraction to visitors. Some remained under or among the gulf-weed at the surface, some concealed themselves in algæ on the bottom, some hid behind stones and other objects in the aquarium, and some sought crevices in rocks. While clumsy in their movements, they were adept in approaching and capturing other fishes. They were quite cannibalistic, one about 6 inches long swallowing another nearly 4 inches long, and they frequently bit off the fleshy dermal appendages of their fellows. In August several spawned in the aquarium. The eggs are connected in long bands like those of the goosefish (*Lophius*). On July 17, 1897, 8 specimens of this fish were taken in gulf-weed off Nantucket. It is reported that in the summer of 1889 the fish was not uncommon in that region.

Coincident with this noteworthy appearance of *Pterophryne* in the summer of 1897, the Portuguese man-of-war (*Physalia*) was more abundant in Vineyard Sound than during any time in the past twenty-five years; on several days in the latter part of August hundreds were in view at one time off Woods Hole.

[1] Recorded from Holmes Hole (Vineyard Haven) by Storer, History of Massachusetts Fishes, 1867.

## II.—FISHES OF THE WOODS HOLE REGION NOT PREVIOUSLY REPORTED SO FAR NORTH OR SOUTH.

The following species, represented in collections or authentically ascertained to inhabit the waters embraced within the limits of this paper, have not before been reported from the region in published ichthyological works. The limits of the previously ascribed range of each are noted.

**Tarpon atlanticus** (Cuvier & Valenciennes). *Tarpon.* Long Island to Brazil.

**Opisthonema oglinum** (LeSueur). *Thread Herring.* Regularly northward to Florida and Carolina, straying occasionally to Virginia, New Jersey, and Rhode Island.

**Trachinocephalus myops** (Forster). *Ground Spearing.* Tropical parts of western Atlantic; common in West Indies and Brazil, and ranging on the Atlantic coast to South Carolina.

**Lucania parva** (Baird & Girard). *Rainwater-fish.* Atlantic coast, from Connecticut to Key West.

**Athlennes hians** (Cuvier & Valenciennes). West Indies, from Florida to Brazil.

**Gasterosteus gladiunculus** (Kendall). Off coast of Maine.

**Polydactylus octonemus** (Girard). *Eight-threaded Threadfish.* New York to the Rio Grande.

**Oligoplites saurus** (Bloch & Schneider). *Leather-jacket.* Both coasts of America, north to New York and Lower California.

**Caranx bartholomæi** Cuvier & Valenciennes. *Yellow-jack.* West Indies northward to Florida and North Carolina.

**Trachinotus goodei** Jordan & Evermann. *Permit; Black-finned Pompano.* West Indies north to southern Florida.

**Neomænis griseus** (Linnæus). *Gray Snapper.* Atlantic coast from New Jersey to Brazil.

**Neomænis jocu** (Bloch & Schneider). *Dog Snapper.* West Indies, north to Florida Keys, south to Bahia.

**Neomænis apodus** (Walbaum). *Schoolmaster.* West Indies, north to Key West, south to Bahia.

**Neomænis aya** (Bloch). *Red Snapper.* Long Island to Brazil.

**Neomænis analis** (Cuvier & Valenciennes). *Mutton-fish.* West Indies, Pensacola to Brazil.

**Larimus fasciatus** Holbrook. *Banded Drum.* Coast of United States from Chesapeake Bay to Galveston, Tex.

**Sciænops ocellatus** (Linnæus). *Red Drum; Channel Bass; Redfish.* Coast of United States from New York to Texas.

**Pogonias cromis** (Linnæus). *Drum.* Atlantic Coast from Long Island to Rio Grande.

**Chætodon ocellatus** Bloch. *Parche.* Havana; Gulf Stream; New Jersey and Rhode Island.

**Chætodon striatus** Linnæus. *Portuguese Butterfly.* West Indies.

**Canthidermis asperrimus** (Cope). *Sobaco.* Darien, Isthmus of Panama.

**Spheroides spengleri** (Bloch). *Southern Puffer; Swelltoad.* West Indies; coast of Texas and of Florida south to Rio Janeiro and to the Madeiras and Canaries.

**Sebastes marinus** (Linnæus). *Rosefish; Red Perch; Bream; Norway Haddock.* North Atlantic, south to Faroe Islands, Maine, and in deep water off coast of middle New Jersey.

## III.—FISHES OBTAINED AT WOODS HOLE NOT YET FOUND ELSEWHERE ON THE UNITED STATES COASTS.

**Stolephorus argyrophanus** (Cuvier & Valenciennes). *Anchovy.*

**Centrolophus niger** (Gmelin). *Blackfish; Black Ruffe.*

**Tetragonurus cuvieri** Risso. *Square-tail; Sea-raven.*

**Chætodon striatus** Linnæus. *Portuguese Butterfly.*

**Chætodon bricei** H. M. Smith. *Brice's Chætodont.*

**Canthidermis asperrimus** (Cope). *Sobaco.*

## IV.—LIST OF FISHES RECORDED FROM ADJACENT LOCALITIES WHICH MAY BE LOOKED FOR AT WOODS HOLE.

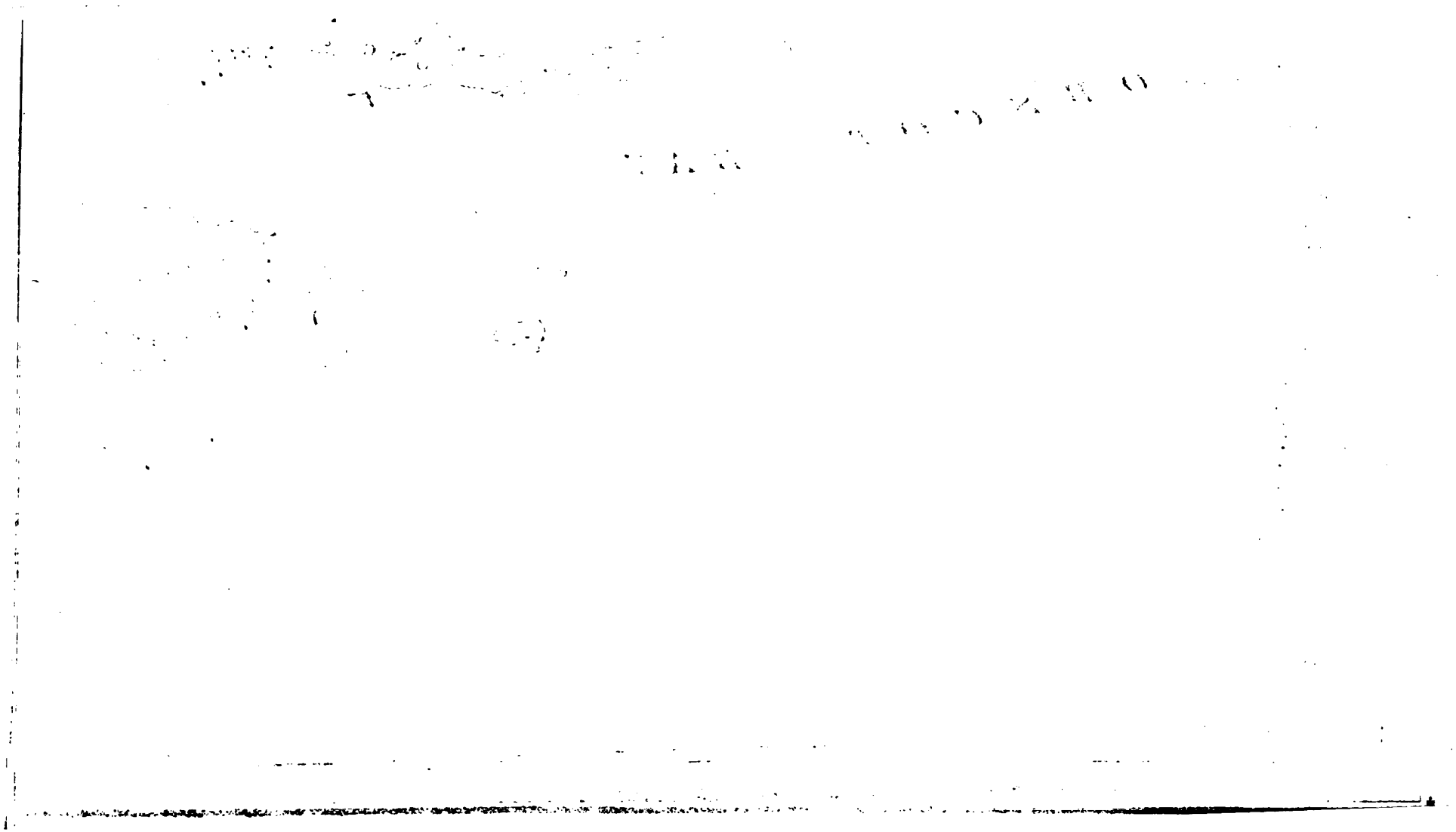
Besides stragglers from the high seas and the West Indies that may from time to time be detected at Woods Hole, a number of species have been obtained within comparatively short distances to the north or south of the region which are liable to be added to the local fauna. Narragansett Bay, for instance, distant only 35 miles, has yielded several species not yet observed at Woods Hole; and there are also some more northern shore fishes regularly found as far south as Cape Cod which are to be looked for in Vineyard Sound. The following list, not by any means complete, is suggestive of the possible augmentation of the already rich fauna of Woods Hole.

**Scoliodon terræ-novæ** (Richardson). *Sharp-nosed Shark.* Cape Cod to Brazil.
**Lamna cornubica** (Gmelin). *Porbeagle; Mackerel Shark.* Newfoundland to West Indies; common on Massachusetts coast.
**Somniosus microcephalus** (Bloch). North Atlantic, south to Cape Cod.
**Dasyatis hastata** (DeKay). *Sting Ray.* West Indies, north to Rhode Island.
**Dorosoma cepedianum** (LeSueur). *Gizzard Shad; Mud Shad.* Cape Cod to Mexico.
**Cypsilurus gibbifrons** (Cuvier & Valenciennes). *Flying-fish.* Atlantic Ocean; Newport, R. I.
**Chloroscombrus chrysurus** (Linnæus). *Bumper.* Cape Cod to Brazil.
**Spheroides testudineus** (Linnæus). *Globefish; Swellfish.* West Indies; in Gulf Stream as far north as Newport, R. I.
**Prionotus tribulus** (Cuvier & Valenciennes). *Sea-robin.* Atlantic coast, north to Long Island.

## V.—FRESH-WATER FISHES COLLECTED IN THE VICINITY OF WOODS HOLE.

In the fresh-water ponds near Woods Hole, a number of fishes are found, some of which have been mentioned in the foregoing list, together with others that are strictly fresh-water species. Besides the white perch (*Morone americana*), spring minnow (*Fundulus diaphanus*), four-spined stickleback (*Apeltes quadracus*), and nine-spined stickleback (*Pygosteus pungitius*) already given, the following have been noted, specimens being preserved in the local collection. Further collecting will doubtless disclose the presence of other species.

**Catostomus commersonii** (Lacépède). *Brook Sucker.*
**Abramis crysoleucas** (Mitchill). *Golden shiner; Roach; Dace.*
**Notropis cornutus** (Mitchill). *Shiner; Red-fin.*
**Hybopsis kentuckiensis** (Rafinesque). *River Chub; Horny-head.*
**Lucius reticulatus** (LeSueur). *Pickerel.*
**Perca flavescens** (Mitchill). *Yellow Perch.*
**Ameiurus nebulosus** (LeSueur). *Horned Pout; Bullhead.*
**Boleosoma nigrum olmstedi** (Storer). *Darter.*
**Eupomotis gibbosus** (Linnæus). *Sunfish.*
**Micropterus dolomieu** Lacépède. *Small-mouth Black Bass.* (Introduced.)
**Micropterus salmoides** (Lacépède). *Large-mouth Black Bass.* (Introduced.)



# 4.—THE SALMON FISHERY OF PENOBSCOT BAY AND RIVER IN 1895 AND 1896.

By HUGH M. SMITH.

During the months of August and September, 1896, the writer visited the shores of Penobscot River and Bay in the interests of the United States Fish Commission, for the purpose of securing data regarding the condition and extent of the salmon, shad, and alewife fisheries. Special attention was given to the salmon fishery, as the Penobscot is now the only important salmon stream on the Atlantic coast of the United States and has been the field for very extensive fish-cultural operations on the part of the Fish Commission. A large majority of the owners of the salmon weirs and nets along both sides of the bay and river were interviewed and accurate accounts of their fishing obtained, together with their observations as to the effect of artificial propagation on the supply.

The history and methods of the salmon fishery of this basin have been well presented in papers by Mr. Charles G. Atkins, superintendent of the Government hatchery at Craig Brook, Maine.* The present paper is primarily intended to show the extent and condition of the salmon fishery of Penobscot Bay and River in 1895 and 1896 and the influence of artificial propagation on the supply. The methods and apparatus of the fishery are briefly considered. A chart of the Penobscot region, giving the location of salmon weirs and traps in use in 1896, is appended, and illustrations of some of the types of salmon apparatus are shown.

*Extent and condition of the fishery in 1895 and 1896.*—While the number of nets operated in these two years was practically the same, the catch in 1896 was much greater than in 1895, and was one of the largest in the recent history of the fishery. A comparatively large number of fishermen reported that they took more salmon than in any previous year. The salmon, however, were smaller than usual, and their market value was but little more in 1896 than in 1895.

The traps set especially for salmon, or in which salmon were taken, numbered 193 in 1895 and 184 in 1896. These, with the accessories, had a value of $12,474 and $13,146, respectively. The boats and scows required in the construction and operation of the nets numbered 188 in 1895, the same in 1896, and were valued at $3,576 and $3,599, respectively. The number of men engaged in the fishery was 127 in 1895 and 126 in 1896. In the comparatively unimportant branch of the fishery carried on with gill nets in the vicinity of Bangor, 10 nets, valued at $189, were used in 1895, and 11 nets, worth $199, in 1896; these were set by 6 men in the first year and 7 in the next. The boats numbered 4 in 1895 and 5 in 1896, and were valued at $29 and $37, respectively.

*(1) On the Salmon of Eastern North America, and its artificial culture. In Report of Commissioner of Fish and Fisheries 1872–73, pp. 226–337, 9 plates of apparatus and methods, and map showing location of salmon weirs in Penobscot region.

(2) The River Fisheries of Maine. In The Fisheries and Fishery Industries of the United States, section V, vol. I, pp. 673–728.

The total number of salmon caught in 1895 was 4,395; these weighed 65,011 pounds and yielded the fishermen $11,356; in gill nets 117 salmon were caught, weighing 1,985 pounds and valued at $323. In 1896 the result of the fishery was 6,403 salmon, weighing 80,175 pounds, with a market value of $12,716; the gill-net catch this year was 246 salmon, with a weight of 3,444 pounds and a value of $492.

The outcome of the fishery in 1896 exceeded that of 1895 by 2,008 salmon; the increase in weight was 15,164 pounds, and in value $1,360. The percentage of increase in these items was as follows: Fish taken, 46 per cent; weight of catch, 23 per cent; value of catch, 12 per cent.

As an illustration of the uniform increase in the number of salmon taken in 1896, the following facts may be cited: The nets that were set in both years numbered 162; of these, 146 nets, or 90 per cent, took more salmon in 1896 than in 1895; and only 16, or 10 per cent, took the same number or less. The comparative figures for the nets that secured more fish in 1896 were 3,449 salmon in 1895 and 5,681 in 1896. The nets whose catch was the same or less in 1896 caught 295 fish in 1895 and 289 in 1896.

The largest number of salmon taken by one fisherman in 1895 was 408; these were caught in 3 nets on the lower side of Sears Island, in the township of Searsport. Other catches by single fishermen in 1895 were 104 salmon in 4 nets in Stockton, 102 in 5 nets in Northport, 150 in 3 nets in Islesboro, and 150 in 3 nets in Verona.

In 1896 the 3 Searsport nets first mentioned took 426 salmon, and a large number of fishermen secured between 100 and 200 fish in 2 to 5 nets. Thus, in Stockton 100 fish were caught in 2 nets, 105 in 3 nets, and 110 in 1 net; in Penobscot 192 salmon were taken in 2 nets, 105 in 2 nets, and 127 in 2 nets; in Northport 5 nets obtained 204 fish and 4 nets 125 fish; in Islesboro 3 nets took 130 fish, 3 nets 150 fish, 4 nets 190 fish, and 2 nets 100 fish; in Verona 3 nets caught 174 fish, 2 nets 106 fish, 3 nets 150 fish, 1 net 100 fish, and 2 nets 170 fish.

About 80 per cent of the fishing is done in that part of the river between the northern end of Whitmore Island and Islesboro. While single weirs in that part of the river between Bucksport and Bangor may take as many as 50 or 60 salmon some seasons, the average was only 14 in 1895 and 26 in 1896, and the aggregate is comparatively small. In the townships of Lincolnville and Camden, which are the lowest points in the Penobscot region at which salmon fishing is done, the average catch to a net in 1895 was only 16 salmon and in 1896 only 19 salmon.

*Detailed statistics for 1895 and 1896.*—The following tables show, by townships, the extent of the salmon fishery of Penobscot Bay and River in 1895 and 1896:

*Persons employed.*

| Towns. | 1895. | 1896. | Towns. | 1895. | 1896. |
|---|---|---|---|---|---|
| Brooksville (Cape Rosier) | 4 | 2 | Orrington | 5 | 5 |
| Bucksport | 10 | 9 | Penobscot | 16 | 15 |
| Camden | 2 | 2 | Searsport | 3 | 2 |
| Castine | 3 | 2 | South Brewer | 2 | 2 |
| Hampden | 1 | 1 | Stockton and Prospect | 17 | 15 |
| Islesboro | 7 | 6 | Verona | 21 | 21 |
| Lincolnville | 7 | 7 | Winterport | 7 | 8 |
| Matinicus and Ragged Islands | 4 | 8 | | | |
| Northport | 7 | 6 | Total | 133 | 133 |
| Orland | 17 | 22 | | | |

*Apparatus, boats, etc.*

| Towns. | Weirs and traps.* | | | | Gill nets. | | | | Boats and scows. | | | | Total investment. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1895. | | 1896. | | 1895. | | 1896. | | 1895. | | 1896. | | 1895. | 1896. |
| | No. | Value. | No. | Value. | No. | Value. | No. | Value. | No. | Value. | No. | Value. | | |
| Brooksville (Cape Rosier) | 7 | $420 | 4 | $240 | .... | ..... | .... | ..... | 3 | $30 | 2 | $20 | $450 | $260 |
| Bucksport | 13 | 511 | 11 | 455 | .... | ..... | .... | ..... | 16 | 270 | 14 | 238 | 781 | 693 |
| Camden | 5 | 200 | 5 | 200 | .... | ..... | .... | ..... | 2 | 45 | 2 | 45 | 245 | 245 |
| Castine | 4 | 252 | 3 | 201 | .... | ..... | .... | ..... | 5 | 25 | 4 | 20 | 277 | 221 |
| Hampden | .... | ..... | .... | ..... | 2 | $26 | 2 | $26 | 1 | 12 | 1 | 12 | 38 | 38 |
| Islesboro | 17 | 925 | 16 | 875 | .... | ..... | .... | ..... | 7 | 94 | 6 | 79 | 1,019 | 954 |
| Lincolnville | 12 | 650 | 14 | 700 | .... | ..... | .... | ..... | 7 | 132 | 7 | 117 | 782 | 817 |
| Matinicus and Ragged Islands | 1 | 1,000 | 2 | 2,500 | .... | ..... | .... | ..... | 2 | 75 | 5 | 195 | 1,075 | 2,695 |
| Northport | 15 | 1,155 | 12 | 1,005 | .... | ..... | .... | ..... | 8 | 163 | 7 | 138 | 1,318 | 1,143 |
| Orland | 19 | 664 | 26 | 858 | .... | ..... | .... | ..... | 25 | 467 | 32 | 535 | 1,131 | 1,423 |
| Orrington | 2 | 99 | 2 | 99 | 5 | 58 | 5 | 58 | 2 | 11 | 2 | 11 | 168 | 168 |
| Penobscot | 24 | 1,587 | 22 | 1,421 | .... | ..... | .... | ..... | 30 | 436 | 28 | 413 | 2,023 | 1,834 |
| Searsport | 4 | 213 | 3 | 152 | .... | ..... | .... | ..... | 6 | 145 | 4 | 125 | 358 | 277 |
| South Brewer | .... | ..... | .... | ..... | 3 | 105 | 3 | 105 | 1 | 6 | 1 | 6 | 111 | 111 |
| Stockton and Prospect | 26 | 1,530 | 20 | 1,183 | .... | ..... | .... | ..... | 33 | 413 | 31 | 383 | 1,943 | 1,566 |
| Verona | 37 | 2,801 | 37 | 2,760 | .... | ..... | .... | ..... | 35 | 1,100 | 36 | 1,110 | 3,901 | 3,870 |
| Winterport | 7 | 467 | 7 | 467 | .... | ..... | 1 | 10 | 10 | 181 | 11 | 189 | 648 | 666 |
| Total | 193 | 12,474 | 184 | 13,146 | 10 | 189 | 11 | 199 | 192 | 3,605 | 193 | 3,636 | 16,268 | 16,981 |

*Includes accessories.

*Catch.*

| Towns. | 1895. | | | 1896. | | |
|---|---|---|---|---|---|---|
| | No. of salmon. | Weight. | Value. | No. of salmon. | Weight. | Value. |
| | | *Pounds.* | | | *Pounds.* | |
| Brooksville (Cape Rosier) | 163 | 2,092 | $283 | 146 | 1,626 | $190 |
| Bucksport | 205 | 2,885 | 448 | 245 | 2,729 | 471 |
| Camden | 64 | 964 | 136 | 71 | 990 | 139 |
| Castine | 77 | 1,150 | 207 | 93 | 1,166 | 156 |
| Hampden | 30 | 510 | 102 | 32 | 448 | 90 |
| Islesboro | 474 | 6,551 | 1,042 | 643 | 8,265 | 1,313 |
| Lincolnville | 205 | 3,240 | 583 | 297 | 3,503 | 525 |
| Matinicus and Ragged Islands | 65 | 780 | 109 | 182 | 1,627 | 175 |
| Northport | 286 | 4,066 | 697 | 418 | 5,401 | 810 |
| Orland | 78 | 1,077 | 202 | 152 | 1,802 | 306 |
| Orrington | 65 | 1,101 | 165 | 82 | 1,150 | 161 |
| Penobscot | 485 | 7,270 | 1,313 | 959 | 12,483 | 1,992 |
| Searsport | 458 | 7,278 | 1,456 | 426 | 5,112 | 818 |
| South Brewer | 63 | 1,071 | 161 | 170 | 2,380 | 309 |
| Stockton and Prospect | 629 | 10,067 | 1,713 | 829 | 10,471 | 1,590 |
| Verona | 908 | 12,555 | 2,337 | 1,421 | 17,761 | 3,172 |
| Winterport | 140 | 2,354 | 402 | 237 | 3,311 | 499 |
| Total | 4,395 | 65,011 | 11,356 | 6,403 | 80,175 | 12,716 |

*Comparative data relative to the salmon fishery.*—In 1880 the catch of salmon in Penobscot Bay and River and their tributaries was 10,016, having an estimated weight of 110,176 pounds. The weirs and traps used numbered 230; the gill nets, 36. The fishery yielded 169,894 pounds, valued at $32,800, in 1887; 192,177 pounds, worth $38,049, in 1888; 140,469 pounds, valued at $31,156, in 1889, and 92,282 pounds, worth $19,124, in 1892.

As previously shown, in 1895 193 traps and 10 gill nets took 4,395 salmon, weighing 65,011 pounds, valued at $11,356, and in 1896, 184 traps and 11 gill nets caught 6,403 salmon, weighing 80,175 pounds, valued at $12,716.

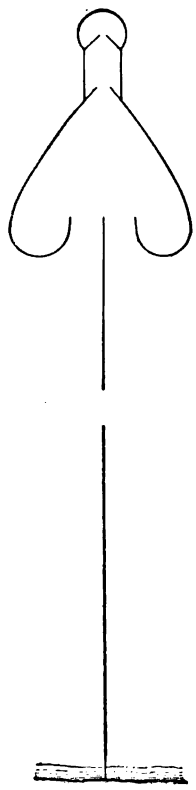
Comparing 1896 with 1880, it appears that there was a reduction of 27 per cent in the number of nets used and a decrease of 36 per cent in the number of salmon caught. A relatively large catch was made in 1887 to 1889, inclusive, and the decrease in 1896, as compared with those years, was marked. From 1892 to 1895 the output declined nearly 30 per cent, and the general tendency for the past eight years has been toward a decrease, 1896 presenting a very pleasing contrast, of which the fishermen all make mention.

Following is a continuous record from 1874 to 1896 of two of the most successful salmon weirs. These are located on the east side of the river, in the town of Penobscot, a short distance from the southern end of Whitmore Island. The number of salmon taken in 1896 was 20 per cent greater than in any previous year and over 93 per cent greater than the average for the preceding 22 years. Similar comparative statements for other nets are at hand, showing the increase in 1896 over previous seasons.

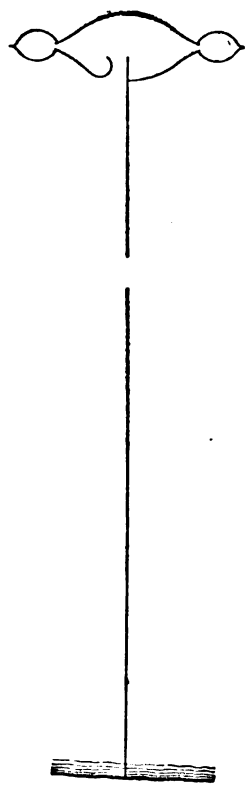
*Record of two Penobscot River salmon weirs, from 1874 to 1896, inclusive.*

| Year. | Date when ice left river. | Date of catching first salmon. | Date of catching largest number of salmon. | Total number of salmon. | Aggregate weight of salmon. | Average weight of salmon. |
|---|---|---|---|---|---|---|
| 1874 | Apr. 20 | Apr. 30 | June 10 | 86 | 1,253 | 14.57 |
| 1875 | Apr. 18 | May 13 | June 15 | 70 | 908 | 12.97 |
| 1876 | Apr. 14 | Apr. 25 | June 17 | 68 | 1,027 | 15.10 |
| 1877 | Mar. 30 | Apr. 24 | June 9 | 72 | 1,002 | 13.92 |
| 1878 | Apr. 4 | Apr. 21 | June 26 | 151 | 2,052 | 13.52 |
| 1879 | Apr. 25 | May 12 | June 20 | 147 | 1,756 | 11.95 |
| 1880 | Apr. 9 | May 7 | May 31 | 86 | 1,111 | 12.92 |
| 1881 | Mar. 21 | Apr. 17 | June 9 | 85 | 1,480 | 17.41 |
| 1882 | Apr. 10 | May 1 | May 29 | 154 | 1,711 | 11.11 |
| 1883 | Apr. 13 | ....do ... | June 12 | 98 | 1,643 | 16.77 |
| 1884 | Apr. 9 | Apr. 29 | June 28 | 95 | 911 | 9.59 |
| 1885 | Apr. 19 | May 8 | June 4 | 91 | 1,104 | 12.13 |
| 1886 | Apr. 16 | Apr. 21 | June 2 | 100 | 1,631 | 16.31 |
| 1887 | Apr. 23 | May 8 | June 25 | 150 | 2,020 | 13.47 |
| 1888 | Apr. 15 | Apr. 29 | June 9 | 159 | 2,196 | 13.81 |
| 1889 | Apr. 2 | Apr. 21 | June 6 | 85 | 1,246 | 14.66 |
| 1890 | Apr. 7 | Apr. 20 | May 30 | 41 | 641 | 15.63 |
| 1891 | Apr. 2 | Apr. 28 | June 9 and 16 | 117 | 1,199 | 10.25 |
| 1892 | ....do ... | Apr. 9 | June 5 | 65 | 989 | 15.22 |
| 1893 | Apr. 15 | Apr. 23 | June 10 | 102 | 1,384 | 13.57 |
| 1894 | Apr. 12 | Apr. 19 | June 1 and 3 | 88 | 1,160 | 13.19 |
| 1895 | Apr. 6 | Apr. 21 | June 3 | 75 | 1,191 | 15.88 |
| 1896 | Apr. 12 | Apr. 16 | June 6 | 192 | 2,524 | 13.15 |

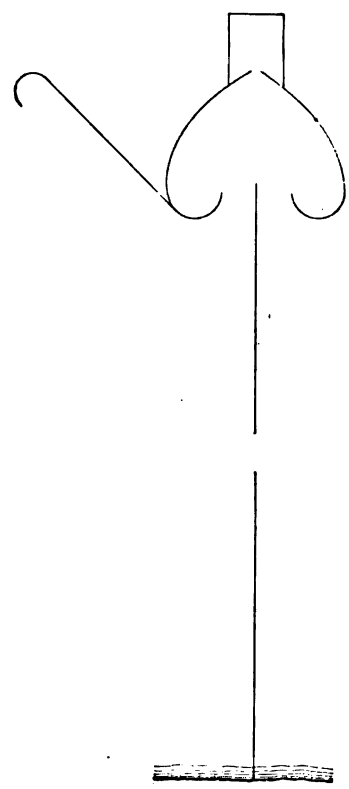
NOTE.—The weirs are set one or two days after the ice moves out. Occasionally they are put in place before the ice leaves.



*n weir, Penobscot.* — Leader of akes interwoven with brush, 175 rds long. "Great pond" brush, feet long. "Middle pond" and back pond," netting with board or, each 10 feet long. Outer en- ance, 16 feet wide; middle, 2 feet; ner, 1 foot. Value, $75.



*Salmon weir, Bucksport.* — Leader, brush, 4 to 8 rods long. Middle pond, 40 feet long, 8-foot entrance; inner side, brush; outer side, twine. Pockets, twine, 10 feet long, 10-inch entrances, wooden floor. Value, $25. Some weirs have only one (upstream) pocket.



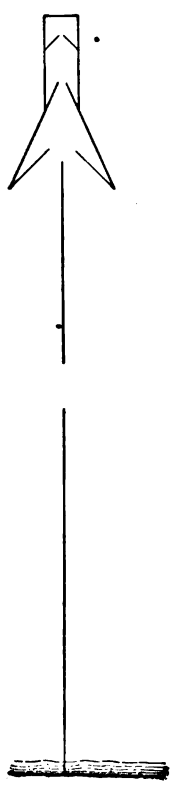
*"Hook weir," Orland.*—A brush hook, about 50 feet long and extending down stream, is built on some of the weirs. It serves the purpose of leading the fish into the net. Value, $35.

*Apparatus and methods of the fishery.*—There is probably no other river in the ted States in which a fishery of such magnitude has undergone so few changes i respect to methods, number of traps operated, and sites where nets are set, as Penobscot. This is chiefly owing (1) to the character of the bottom, (2) to the that the fishing is a riparian privilege enjoyed only by those who own land ting on the water, (3) to the circumstance that the fishing is almost entirely of a iprofessional character, and has been taken up by generation after generation as rt of the regular duties connected with the small farms, and (4) to the small number ood-fishes occurring in the river, and the preponderating importance of two of n—the salmon and the alewife—for which the nets are exclusively set.

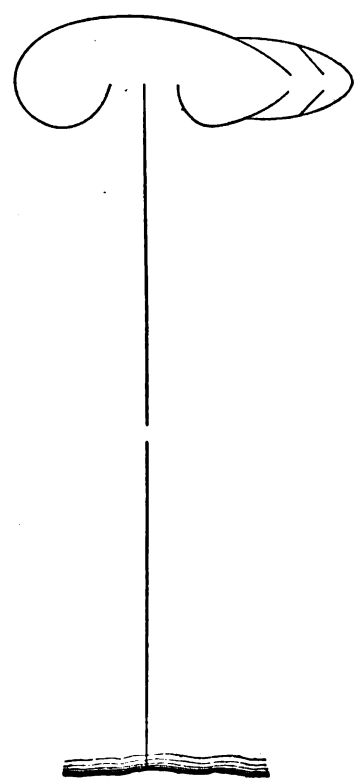
The salmon fishery of the Penobscot basin is carried on with practically a single ; of apparatus, namely, the brush weir. In most parts of the region this trap is l in the same form that it had in the primitive days of the fishery, but in some ions the weir has undergone evolution into a combination brush and twine trap, in places into a trap made wholly of netting.

Some of the types of salmon nets used in this region are illustrated and described by the accompanying figures. In addition to these, which are wholly or partly of brush, a common apparatus is the floating trap, constructed entirely of twine, such as is now generally employed in the New England States. This is the only salmon net in use at Islesboro and in some other sections. The local and individual variations in the form of the nets depend on the topography of the bottom and shore and the habits of the salmon, and are the result of long experience.

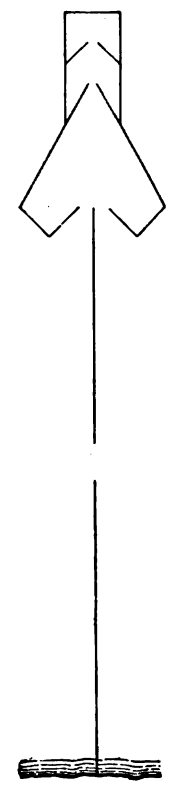
The fishing begins as soon as the ice moves out in spring and continues until some time in July. Fish are rarely taken before the last two weeks in April. May and June are the best months. In that part of the river adjacent to Bangor there is a small fishery prosecuted with set gill nets. The nets are from 100 to 200 feet long and have a 6-inch mesh.



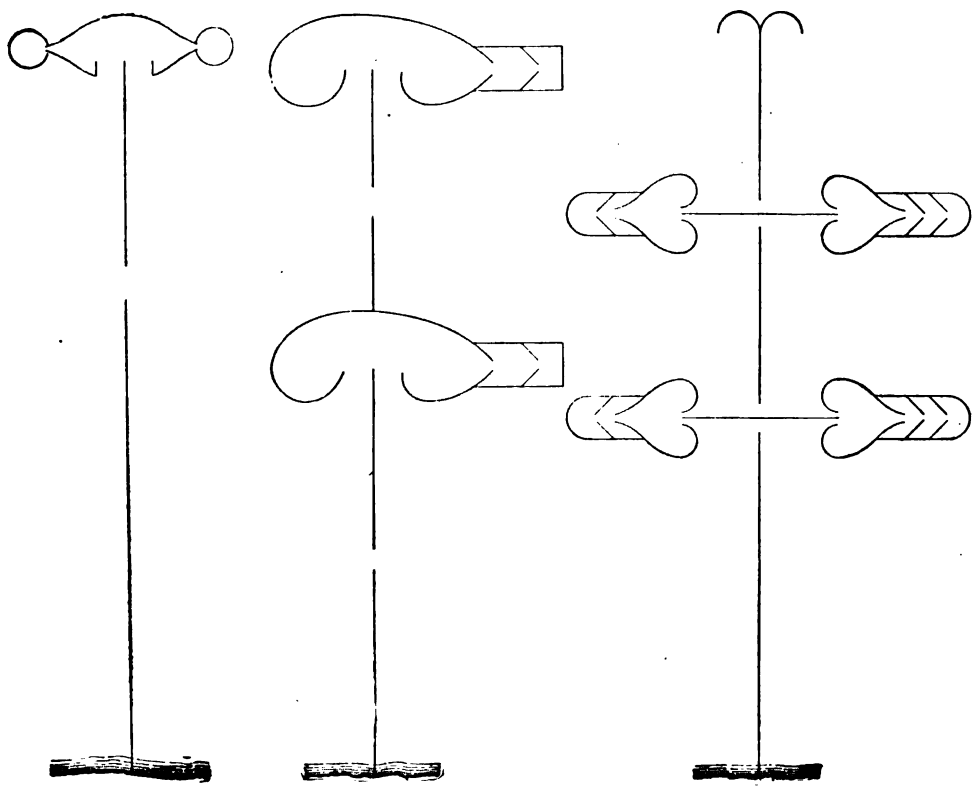
*Salmon weir, Castine.*—Hedge 200 feet long, made of stakes driven in mud interwoven with brush to low-water mark, covered with netting beyond. Great pound, 30 feet long, 30 feet wide at base, made of netting; entrance 8 feet wide. Inner pounds, 10 feet wide, with board floors; outer entrance 2 feet wide, inner 1 foot. Value, $70.



*Salmon weir, Stockton.*—Leader or hedge, 400 yards long, all brush except 20 yards next to head, which piece is netting above low-water mark and brush below. Main compartment or great pound 60 feet long and 25 feet wide, with 10-foot entrance on each side of leader. Smaller compartments, directed downstream, 21 feet long, with 2-foot entrance to first and 8-inch entrance to second. Value, $100.



*Salmon weir, Stockton.*—Leader 200 feet long; brush from shore to low-water mark; remainder brush at bottom, netting at top. Head 60 feet long; outer pound 40 feet, middle pound 12 feet, inner pound 8 feet; brush below low-water line, netting above; plank floors in two smaller compartments. Value, $40.



*lmon weir, Winterport.*—Leader, ›rush, 6 rods long. Heart, brush or ıetting, 40 feet long, 20 feet wide, ›ith 8-foot entrance on each side of eader. Pockets, netting, 10 feet in liameter, 9-inch entrance, wooden loor. Value, $50.

*"Up and down" Salmon weirs, Orland.*—Constructed of brush except final compartments, which are of netting with wooden floors. Value of set, $65

*Salmon weir, built at Verona in 1889.*—The most elaborate net used in the Penobscot region.

*Salmon at Matinicus and Ragged islands.*—Matinicus is a small island located south Penobscot Bay and about 15 miles southeast of the nearest mainland (Thomaston). s in the route of salmon coming in from the sea to ascend the river, and nets set in orable positions would naturally be expected to intercept the fish. On the western e of the island Messrs. R. Crie & Sons have operated a trap for mackerel and ring for four years, and during that time have incidentally taken a number of mon. Between May 20 and July 10 marketable fish are caught, while in August l September salmon too small to utilize are taken in considerable quantities; in opinion of the Messrs. Crie these small fish were on their way to sea from the ıobscot River. It has been observed that when an easterly wind is blowing very salmon are taken, but during a westerly wind salmon are always obtained in the ıths named, and the quantity of salmon secured in any given year bears a close ıtion to the direction of the prevailing winds. In 1895 the number of marketable non caught was 65; in 1896 the catch was 167. The largest fish taken in the two rs weighed 30 pounds, the smallest ½ pound. The largest daily catch was 31 non, in 1896; the next largest, 27, in 1894.

Mr. W. B. Young, of Matinicus Island, has a herring weir on the southwestern part of Ragged Island, which lies a short distance south of Matinicus Island. In 1896 this weir during June and July caught 15 salmon with an aggregate weight of 200 pounds. The largest weighed 24½ pounds. No small, unmarketable ones were obtained.

*Salmon at the Cranberry Isles.*—The Cranberry Isles lie a few miles south of Mount Desert Island and about 25 miles east of Penobscot Bay. They are in the track of migrating salmon, as a few herring weirs set around the islands have for several years taken one or more salmon almost annually.* Mr. W. I. Mayo, a correspondent at the islands, reports that in June, 1895, Colonel Hadlock took a 17-pound salmon in a weir, and on May 5 of the same year Mr. Mayo caught one weighing 19 pounds. None had been taken, however, in 1896 up to September 1.

*Salmon caught with hook off Maine coast.*—Instances are multiplying of the taking of salmon at sea on trawl lines on the New England coast. The salmon are usually taken during the time when the fish are running in the rivers, but occasionally one has been caught in midwinter. The following data relate to fish that probably belonged to the Penobscot school.

On June 19, 1896, a Gloucester fishing vessel brought into Rockland a 10-pound salmon that had been caught on a cod trawl 20 miles southeast of Matinicus. The fish was sent home to Gloucester by the captain of the vessel, through Mr. Charles E. Weeks, a Rockland fish-dealer.

Several salmon have been taken on hooks off Frenchman Bay within a few years. One 25-pound fish was caught on a cod trawl 3 miles off Gouldsboro, in 20 fathoms of water, and another was taken southeast of Mount Desert Island in 35 fathoms.

Some years ago, on May 22, one of the crew of the schooner *Telephone*, of Orland, Me., while fishing for cod on German Bank, caught a 10-pound salmon. German Bank lies about 50 miles southeast of Mount Desert Island and has 65 to 100 fathoms of water.

*Destruction of salmon by seals.*—Seals are known to kill a great many salmon in Penobscot Bay and the lower river. They enter and leave the weirs and traps without difficulty and cause great annoyance to the fishermen. When a seal enters a net, the fish are frightened and usually become meshed; the seal may then devour them at its leisure. The initial bite usually includes the salmon's head.

Fishermen in some places report a noticeable increase in seals in the past few years, and a consequent increase in damage done to the salmon fishery. The State pays a bounty of $1 each for seal scalps, which serves to keep the seals somewhat in check, although the sagacity of the animals makes it difficult to approach them with a rifle and to secure them when shot. Within a few years some weir fishermen have been obliged at times to patrol the waters in the vicinity of their nets, in order to prevent depredations. In the Cape Rosier region, where some salmon trap fishing is done, seals were very troublesome in the early part of the season of 1896. Mr. George Ames, who set three traps in 1896 and took about 100 salmon, had knowledge of 13 other salmon that were destroyed by seals while in his nets. Similar instances of relatively large numbers of salmon killed by seals might be given. With salmon worth 20 to 50 cents a pound the loss of 10 or 12 salmon by seals, in a total catch of 75 or 100, is a matter of importance to the fisherman.

* See paper entitled "Notes on the capture of Atlantic salmon at sea and in the coast waters of the Eastern States," Bull. U. S. F. C. 1894.

*Evidences of results of propagation.*—The opinion is now practically unanimous among the salmon fishermen of Penobscot River and Bay that the artificial hatching of salmon by the U. S. Fish Commission is producing beneficial results. About the same arguments in support of their opinions are presented by all, and these accord well in the main with the observations of other persons who have given this matter attention:

(1) The opportunities for natural reproduction are exceedingly limited, owing to the obstructions to the passage of the fish to their spawning-grounds in the headwaters of the Penobscot basin.

(2) The salmon that are naturally hatched are, even under the most favorable conditions prevailing at the present time, not numerous enough to keep up the supply of market and brood fish, with the fatalities incident to the long residence at sea and to the passage of immature fish down from the spawning grounds to the sea.

(3) The remarkable run in May and June, 1896, of fish of comparatively small size that had apparently just reached maturity and the relative scarcity of large fish that had evidently been in the river during one or two previous seasons seemed to show a tendency toward the depletion of the run of old fish and the substitution of a run of young, artificially hatched fish.

(4) A feature of the salmon supply in recent years, on which the fishermen nearly all lay considerable stress, is that the runs in April and July, which in former years were often quite important and remunerative, have of late been very poor, although the fish constituting them are of large size, while the runs in May and June have kept up, but have consisted chiefly of comparatively small fish. In this the fishermen believe they see evidence of the work of the hatchery, for the young salmon artificially hatched have been from eggs of May and June fish, and the fishermen think that such young fish, when they return to the river to spawn, will come at about the same time that their parents did.

Many salmon fishermen might be quoted on the question of results of propagation. A few sample statements and records of salmon taken will be given covering different parts of the bay and river.

Mr. Francis French, an experienced salmon fisherman of Stockton, on the western side of Penobscot Bay, reports that of the 61 salmon taken in his weir in 1896, 56 were under 11 pounds in weight, and all evidently belonged to the same year's brood. In 1895 the 29 salmon obtained by Mr. French averaged 20 pounds each. According to his observations, a very large percentage of the salmon in the Penobscot region in 1896 were hatchery fish that then entered the river for the first time.

Mr. A. H. Whitmore, a salmon fisherman of over thirty years' experience, who fishes three weirs off the southern end of Whitmore Island, states that in that part of the river the catch in 1896 was the largest in thirty years, with the exception of one season. He thinks there is no doubt whatever of the beneficial results of artificial propagation, as shown by the maintenance of the supply when obstructions to the passage of salmon to the upper waters must greatly curtail natural spawning.

Mr. Joseph Hurd, of Winterport, has two weirs at Oak Point, which is the upper limit of weir fishing for salmon on the west side of the river; the nets are about 12 miles below Bangor; 25 salmon were taken in 1895, and 60 in the following year. The catch was better in 1896 than in a number of years. Eight years before, Mr. Hurd

took 140 salmon, which was the best season in his experience; since then the fish have been decreasing until 1896. He thinks very few fish get to their spawning-grounds, owing to dams and other obstructions in the river above Bangor, and has no doubt the small fish which were so conspicuous in 1896 were from the Government hatchery.

Mr. William F. Abbott, of Verona, who has two weirs on Whitmore Island, caught 41 salmon in 1895, and 80 in 1896. He makes the following statement:

> In my opinion, there would not enough salmon come into the river to pay for building weirs if there had been no salmon artificially hatched; and I hope the Government will continue to keep the salmon fishing up, so it will pay to build our weirs. No person that knows anything about it can doubt that it is a good thing for the fishermen.

Mr. Harvey Heath, of Verona, has two weirs on the eastern side of the southern end of Whitmore Island. He caught 62 salmon in 1895, and 100 in 1896. He thinks that the removal of obstructions to the passage of fish to their spawning-grounds would be all that is necessary to secure a good run of fish in the river, but believes that under present conditions the salmon-cultural work of the Government is very useful in sustaining the fishery.

Three weirs of Mr. E. A. Bowden, located on the eastern side of Whitmore Island, above those of Mr. Heath, took 31 salmon in 1895, and 85 in 1896. Mr. Bowden says:

> I think that if it was not for the hatchery we would not have any salmon to speak of, for all the school we have is in June. April, May, and July salmon are very scarce.

Mr. Charles G. Atkins, superintendent of the government salmon hatchery in Orland, Me., informs the writer that he has been inclined to believe that each year a great many salmon succeed in reaching their spawning-grounds; but recent observations have caused him to change his mind, and he is now of the opinion that only relatively few salmon elude the traps, weirs, and gill nets, surmount the dams and fishways, escape the poachers, and succeed in depositing their eggs under conditions favorable to their development. The dam at Bangor, while certainly a formidable obstruction to the passage of fish, is probably passable at high water. It is provided with a fishway, and some fish are known to surmount the dam by this means. Above Bangor, in the main river, there are dams at Great Works and Montague, the dam at Montague being an especially serious obstruction, although it is provided with a good fishway. Below the dam at Bangor there is little poaching, but below the other dams—especially at Montague—comparatively large numbers of salmon are sacrificed by the illegal use of the spear and drift net. In 1896 all the salmon below Montague were at the mercy of poachers after July 15, when all wardens on the river were laid off. The supply of spawning fish was thus greatly reduced. The people above Bangor have no interest in preserving the salmon supply of the river, as they receive none of the benefits from fishing which are enjoyed by fishermen of the lower river.

This year Mr. Atkins, having this matter under consideration, visited the east branch of the Penobscot River. A certain tributary of the east branch, which was said to be one of the best spawning-grounds for salmon in the Penobscot basin, was obstructed by a dam in the spawning region. The dam was impassable to fish in July, and had been so during the previous months. In a deep pool below the dam, which was reported to be a favorite resort for salmon each season, no salmon were found. In other words, if the salmon had reached this stream they could not have gotten above the dam, and would undoubtedly have congregated in the pool mentioned and been noticed, but no fish had ascended even that far.

*Extension of salmon-hatching operations on the Penobscot.*—The establishment of branch hatcheries has been suggested in order to utilize the spawning salmon in the region which lies above commercial fishing, and thus increase by artificial means the production of young fish. It is well known that even under the best conditions now prevailing in our streams the eggs of anadromous fishes like the salmon and shad are liable to numerous destructive agencies; that only a small percentage of the eggs laid under natural surroundings ever hatch, and that the young are subject to heavy mortality up to the time when they leave the river and enter the salt water. Probably 5 per cent would be much too large an estimate of the number of salmon eggs which in a state of nature produce fish that reach the ocean. Fish-culture, on the other hand, hatches 95 per cent of the eggs and raises 75 per cent of the fry to the age of yearlings. Of 206,350 Atlantic salmon eggs obtained in 1895 at the government station at Craig Brook, 206,109 were hatched and 151,761 yearling fish were liberated in the fall. The percentage of eggs hatched was thus 99.88 and the percentage of yearlings raised was 78.39. This is sufficient ground for interfering with the salmon even after they have reached their spawning-beds, and justifies the establishment of hatcheries in the headwaters of the Penobscot, provided the supply of fish in any section is large enough to insure a reasonable take of eggs.

No examinations of the upper tributaries of the Penobscot thus far made have disclosed the existence of any stream on which the construction of a branch salmon hatchery is warranted, owing to the few salmon obtainable. The matter deserves further investigation, however, and will receive due consideration at an early date. It is thought that a satisfactory supply of fish may be secured by constructing a dam or rack which will intercept fish in the main stream and lead practically the entire run into one tributary, where they may be retained.

The operation of a branch salmon hatchery in the river above Bangor would of course depend on the successful working of the fishways and the enforcement by the State of the anti-poaching laws.

*Planting of quinnat salmon and steelhead trout in Maine streams.*—The United States Fish Commission is making the experiment of planting large numbers of non-indigenous salmon in the Penobscot Basin and other Maine waters with a view to test whether the fishes are adapted to those streams. The species with which trials have thus far been made are the quinnat or chinook salmon (*Oncorhynchus tschawytscha*) and the steelhead trout (*Salmo gairdneri*). It is intended to plant sufficiently large numbers of yearling fish to fully test the feasibility of the project; and in the event of success two extremely valuable species will have been added to the fishery resources of the Maine streams.

During the years 1896 and 1897 over 2,000,000 young quinnat salmon and steelheads were deposited by the Commission in the Penobscot River and adjacent waters, several hundred thousand of which were four to six months old. The planting of additional fry and yearlings is contemplated in order to thoroughly demonstrate whether their introduction is possible.

The quinnat salmon ranges along practically the entire Pacific Coast of North America north of Mexico, entering all suitable streams. It is the most valuable member of the salmon family, and is taken in very large quantities for canning, salting, and fresh consumption. Its flesh is very rich and of a deep-red color. It is caught in the rivers with gill nets, seines, pound nets, traps, weirs, wheels, and other

appliances. In Monterey Bay, California, large numbers are taken with trolling hooks baited with small fish, and, although the fish abstains from food after entering the fresh waters, it may often be lured with artificial or other baits. The chinook salmon begins to enter the California rivers in February, the Columbia in March, and the Alaskan rivers in May and June. The spawning season covers six months, extending from June to December, although the spawning period in any given basin is more limited, seldom exceeding one or two months. The highest accessible positions in the streams are sought by the spawning fish, which make rounded excavations in gravelly bottoms, in which the eggs are deposited. The vitality of the fish rapidly decreases after spawning, their bodies become mutilated and diseased, and in a short time they die.

The steelhead (*Salmo gairdneri*), also known by the names of salmon trout, winter salmon, and Gairdner's trout, closely resembles the Atlantic salmon in size, form, and habits. It is found from southern California to Alaska, and enters the coast rivers in large numbers. Its flesh is light-colored, but is of excellent flavor, being not inferior to the eastern salmon. It is caught in large quantities with gill nets and traps, for canning and use in a fresh condition. As a game fish the steelhead enjoys a high reputation in the Pacific States. Its principal run in the rivers is during the fall and winter months, when it ascends the streams long distances, spawning in late winter or early spring.

In order that anglers, fishermen, fish-dealers, and others may be able to distinguish from the Atlantic salmon and from each other any specimens of quinnat salmon and steelhead that come to their notice, the following key* has been prepared to cover the principal differential characters, and illustrations of the three species are shown:

I. Anal fin elongate, with 16 rays; gillrakers 9 + 14; branchiostegals 15 to 19; pyloric cæca 140 to 180; caudal fin considerably forked; average weight about 20 pounds, maximum 100 pounds ..... *Quinnat salmon.*

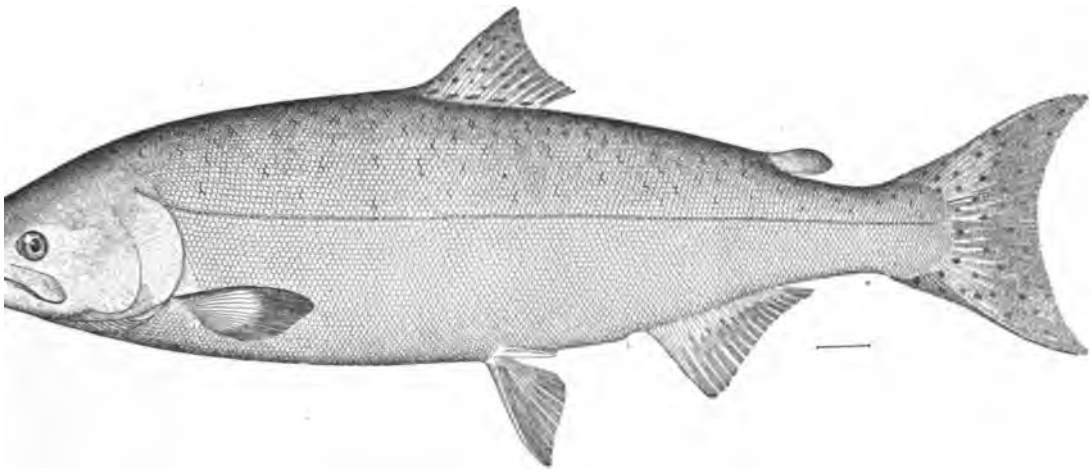
II. Anal fin short, with 9 to 12 rays; gillrakers 8 + 12; branchiostegals 11; pyloric cæca less than 70.

1. Teeth on vomer little developed, those on shaft few and deciduous; scales large, about 120 in lateral series; pyloric cæca 65; caudal fin emarginate; average weight 15 pounds, maximum 40 pounds ..... *Atlantic salmon.*

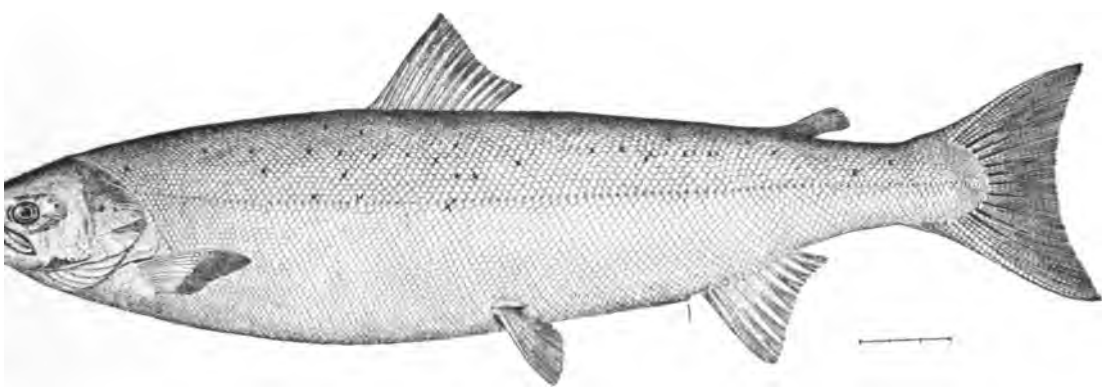
2. Teeth on vomer well developed, those on shaft of bone numerous and persistent in a zigzag row or two alternating series; scales about 150 (130 to 180) in lateral series; pyloric cæca 42; caudal fin squarely emarginate; average weight 10 pounds, maximum 20 pounds ..... *Steelhead trout.*

*The parts referred to in the key may be defined as follows: Anal fin, the single fin on the median line of the body, between the vent and the tail; gillrakers, bony protuberances on the concave side of the bones supporting the gills; branchiostegals, small bones supporting the lower margin of the gill cover; pyloric cæca, worm-like appendages of the lower end of the stomach; vomer, a bone in the front part of the roof of the mouth.

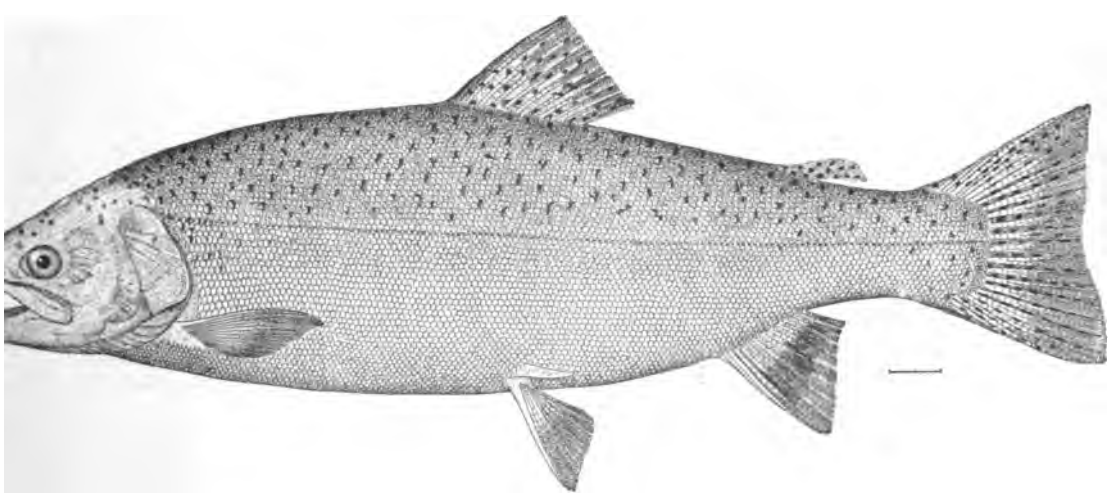
PLATE 5.



CHINOOK OR QUINNAT SALMON (*Oncorhynchus tschawytscha*).



ATLANTIC SALMON (*Salmo salar*).



STEELHEAD TROUT (*Salmo gairdneri*).

# 5.—DESCRIPTIONS OF NEW OR LITTLE-KNOWN GENERA AND SPECIES OF FISHES FROM THE UNITED STATES.

By BARTON W. EVERMANN and WILLIAM C. KENDALL.

The recent investigations of the United States Fish Commission in Florida, Louisiana, and elsewhere have resulted in large and important collections of fishes from those regions. The preliminary study which has been given to these collections has shown that they contain a number of species new to science, besides several others which have not hitherto been taken in the waters of the United States, or are of rare and unusual occurrence within our limits. Among the collections of especial interest which have not yet been fully studied are those made in the St. Lawrence Basin in 1894, in Florida in 1896, and in Louisiana and Mississippi in 1897. A multiplicity of duties having delayed the completion of the detailed reports, it has been thought desirable to publish in advance, in the present paper, descriptions of three new genera and eight of the new species. Descriptions are also given of *Anisotremus surinamensis* and *Lophogobius cyprinoides*, species not until now known to occur in our waters. Illustrations are presented, showing both the male and female of the Alabama shad.

**1. Ictalurus anguilla**, new species. *Eel Cat; Willow Cat.* (Pl. 6, fig. 1.)

Type, No. 48788, U. S. N. M., a ripe female, 14 inches long. Cotypes, No. 48787 and 48789, U. S. N. M.; No. 1078 and 1079, U. S. F. C.; and No. 5772, L. S. Jr. Univ. Mus. Type locality, Atchafalaya River, Louisiana. Collectors, Evermann and Chamberlain.

Head 4; depth 4¼; eye 7 in head; snout 2½; interorbital 1½; maxillary (without barbel) 3; free portion of maxillary barbel longer than head; dorsal spine 2 in head; pectoral spine 2; width of mouth 2. D. I, 6; A. 24; vertebræ 42. Head large, broad, and heavy; the mouth unusually broad; cheeks and postocular portion of top of head very prominent; interorbital space flat, a broad, deep groove extending backward to origin of dorsal fin; body stout, compressed posteriorly; back scarcely elevated. Eye small; maxillary barbel long, reaching considerably past gill-opening; other barbels short. Origin of dorsal fin equidistant between snout and origin of adipose fin, its distance from snout 2⅗ in length of body; base of dorsal fin 3½ in head; longest dorsal ray 1¾ in head; dorsal spine strong, entire both before and behind; pectoral spine strong, entire in front, a series of strong, retrorse serræ behind; humeral process 2½ in pectoral spine; ventrals barely reaching origin of anal, their length 2 in head; anal fin long and low, the longest rays about 2½ in head; base of fin greater than head, 3⅓ in body; caudal moderately forked, the middle rays about 2⅓ in outer rays, which are about 1⅔ in head.

Color, uniform pale yellowish or olivaceous; no spots anywhere.

An examination of the 6 cotypes shows that there is not much variation, all the important characters remaining quite constant. The maxillary barbel varies somewhat in length, in some individuals scarcely reaching gill-opening, and the number of anal rays varies from 24 to 26.

A comparison of the skull of this species with that of *I. furcatus* and *I. punctatus* of the same size shows a number of very marked differences. Nearly all the bones in *I. anguilla* are heavier than

in the other species; the supraoccipital is broadly triangular, and its upper surface finely grooved, while in each of the other species it is much longer and narrower and the upper surface nearly smooth.

From the blue cat (*Ictalurus furcatus*) this species differs chiefly in the fewer rays in the anal fin, the wider mouth, the shorter, heavier head, the much longer maxillary barbel, and in the cranial characters already given. From the spotted cat (*I. punctatus*) it may be distinguished by its wider mouth, more blunt snout, heavier head, the color, and the cranial characters already mentioned.

This species is well known to the fishermen of the Atchafalaya River, by whom it is usually called the "eel cat," though the name "willow cat" is sometimes applied to it. It was explained by the fishermen that the name "eel cat" was given on account of the long feelers (i. e., barbels) and the name "willow cat" because it is most frequently found about the roots of willow trees. The eel cat is not an abundant species in the Atchafalaya River. During six days (April 19–24) spent at Morgan City, several hundred catfish were examined at the three fish-houses, and the total number of eel cats seen was fewer than twenty-five. The fishermen report that this proportion is about as great as at any time of the year. Of the four commercial species of catfishes handled on this river the most abundant one is the blue cat (*Ictalurus furcatus*), and the next is the yellow cat or goujon (*Leptops olivaris*); the eel cat comes next and the spotted cat (*Ictalurus punctatus*) last. The blue cat and the yellow cat probably constitute 98 per cent of the entire catch.

The eel cat rarely attains a greater weight than 5 pounds, and usually does not exceed 3 pounds. Its flesh is firm and of excellent flavor. The spawning season appears to be during the spring, as several of the individuals examined were in mature spawning condition.

Etymology, from *Anguilla*, the generic name of the eel.

**2. Notropis hudsonius** (DeWitt Clinton). (Pl. 6, fig. 3.)

A specimen of this species, collected by Mr. George D. Head, at Kilpatrick Lake, Minnesota, presented certain peculiarities in the dental formula (2, 5–4, 2) and coloration which led us at first to identify it as an undescribed species. But other specimens subsequently received from the same lake show that all belong to the very variable *N. hudsonius*. The presence of 5 teeth on one side in the inner row and 2 in each of the outer rows is an unusual combination for a species of *Notropis*, and this is, so far as we are aware, the first record of the fact. As long ago as 1886 one of us called* attention to the strong tendency of *N. hudsonius* to vary in this character. The specimen with the unusual number of teeth may be described as follows:

Head 4¼; depth 4¼; eye 3⅓ in head; snout 3⅓; maxillary 3⅓; interorbital width 3; D. 8; A. 8; scales 7–43–4. Teeth 2, 5–4, 2, hooked and with evident grinding surface. Body moderately long, slender, and compressed; profile of back rising gently to origin of dorsal; head moderate; mouth rather large, oblique, lower jaw included, the maxillary nearly reaching vertical of pupil; snout blunt, forming an angle in front of nostrils; eye large, in axis of body; caudal peduncle long and slender. Fins moderate; dorsal, anal, and pectoral each somewhat falcate; longest dorsal ray equal to length of head, 1¼ greater than base of fin; longest anal ray 1½ in head; pectoral 1½ in head, not nearly reaching insertion of ventrals; ventral short, 1½ in head, not reaching vent; caudal widely forked, the lobes subequal and nearly equal to length of head; origin of dorsal slightly in front of base of ventral, nearer tip of snout than base of caudal. Scales large, regularly imbricated, 15 before the dorsal; lateral line complete, gently decurved above the pectoral. Color in alcohol, dark olivaceous on back; sides and under parts rich satiny silvery, everywhere showing steel-blue iridescence; upper parts of head dark, lower parts silvery; a black blotch at base of caudal fin, as usual in this species; fins all plain.

**3. Notropis welaka**, new species. (Pl. 6, fig. 2.)

Type, No. 48786, U. S. N. M. Cotypes, No. 48785, U. S. N. M.; No. 529, U. S. F. C.; and No. 5773, L. S. Jr. Univ. Mus. Type locality, St. Johns River, near Welaka, Florida, where numerous specimens were collected March 19, 1897, by Dr. Kendall.

Head 4¼; depth 5; eye 3 in head; snout 3¼. D. 8; A. 8 or 9; scales 6–35–3; teeth 4–4, hooked. Body rather slender, moderately compressed; head short, snout bluntly pointed; mouth moderate somewhat oblique, lower jaw slightly included, maxillary scarcely reaching front of eye; premaxillaries protractile. Eye large; posterior edge of pupil at middle of longitudinal length of head; interorbital width greater than eye; caudal peduncle long and slender. Dorsal fin inserted well behind base of ventrals, a little nearer base of caudal than tip of snout, its longest rays shorter than head

* Fishes of the Monongahela River, in Ann. N. Y. Ac. Sci. 1886, 338.

but slightly longer than longest anal rays; anterior dorsal and anal rays longest; pectoral 1½ in head; ventrals reaching origin of anal; caudal deeply notched, the lobes long and pointed. Scales large, lateral line incomplete, developed only on 6 to 10 scales. Back olivaceous; side with a broad black band extending from snout through eye, and ending in a rather distinct black spot on base of caudal, the black spot in some specimens (probably mature males) surrounded by orange; the black line bordered above by a narrow orange or reddish line, less distinct, or even whitish, in females and immature individuals; under parts plain; fins all plain; dorsal and caudal somewhat dusky; dusky specks on body along base of anal and under side of caudal peduncle; lower jaw tipped with dusky.

This species resembles *Notropis anogenus*, but differs in having the mouth somewhat larger and less oblique, the lower jaw more included, the body more slender, the lateral line less developed, the dorsal fin more posterior, and the anal rays more numerous. It was found in considerable abundance in the St. Johns River near Welaka, Florida.

Etymology, *welaka*, from the type locality.

**4. Alosa alabamæ** Jordan & Evermann. *Alabama Shad.* (Pl. 7, fig. 5, male, and fig. 6, female.)

*Alosa alabamæ* Jordan & Evermann, in Evermann, Rept. U. S. F. C. 1895 (December 28, 1896), 203–205.

Since the publication of the original description of this species some additional information has been obtained regarding the occurrence of shad in the streams tributary to the Gulf of Mexico.

During the season of 1897 the run of shad in the Black Warrior River at Tuscaloosa seems to have been unimportant. During the investigations in the South in April, 1897, some testimony was obtained indicating that there is usually each year a large run of shad at Mobile. That the fish is not taken there in large numbers is due, it is claimed, to the fact that suitable apparatus is not used.

Some inquiries made at Montgomery failed to elicit any definite information concerning the occurrence of shad in the Alabama River at that place. The same inquiries made at the mouth of Pearl River and at different places along the Atchafalaya, Sabine, and Neches rivers yielded similar results. No one of those interviewed had ever seen real shad in any of these rivers. The Atchafalaya fishermen use for bait on their set-lines what they call shad, but they are *Dorosoma, Signalosa,* and *Hiodon*. "Shad" have been from time to time reported from the larger rivers of Arkansas; also from the Ohio and the Great Kanawha; but whether they are *Alosa alabamæ* or some other species has not been determined.

**SIGNALOSA**, new genus of *Clupeidæ*, allied to *Alosa* and *Dorosoma*.

Type: *Signalosa atchafalayæ* Evermann & Kendall.

Body short, deep, and compressed, the form somewhat elliptical; ventral outline more strongly curved than the dorsal; head rather large, snout sharp and pointed, not tumid; mouth small, oblique, the lower jaw scarcely included; maxillary of three pieces, broad and curved, but without notch in the outer margin as in *Dorosoma;* caudal peduncle short and deep. Branchiostegals 5; pseudobranchiæ large; gillrakers short and very numerous, about 340 in number. No teeth; adipose eyelid present; stomach gizzard-like; scutes about 6 + 10. Last ray of dorsal very long and filamentous.

This genus is allied to *Dorosoma*, from which it is plainly distinguished by the absence of the notch in the maxillary, the more pointed snout, the less-included lower jaw, the shorter anal fin, larger scales, and the fewer scutes. It differs from *Alosa* in the very numerous gillrakers, the character of the dorsal fin, and in other respects.

Etymology, *signum*, a flagstaff or pole; *Alosa*, the shad; a reference to the long dorsal ray.

**5. Signalosa atchafalayæ**, new species. (Pl. 7, fig. 4.)

Type locality, Atchafalaya River at Melville, Louisiana. Type, No. 48790, U. S. N. M. Cotypes, No. 48791, U. S. N. M.; No. 532, U. S. F. C.; and No. 5775, L. S. Jr. Univ. Mus. Collector, F. M. Chamberlain, May 5, 1897. Associate type localities, Grand Plains Bayou and Black Bayou, Mississippi. Collectors, F. M. Chamberlain and H. R. Center.

Length of type, 4⅞ inches to base of caudal, or 5⅞ inches to tips of caudal rays.

Head 3⅗; depth 3⅓; eye 3½ in head; snout 5½; maxillary 3⅓; D. I, 12; A. I, 24; scales 42–15; scutes 17+10. Body oblong-elliptical, compressed, the back in front of dorsal narrow; ventral edge sharp, serrate; head small, mouth terminal, oblique, lower jaw slightly included; snout rather pointed, not blunt, as in *Dorosoma cepedianum;* maxillary in 3 pieces, long and curved, reaching vertical at front of pupil, the outer edge not notched; no teeth. Caudal peduncle short, compressed, and deep. Origin of dorsal fin over base of ventrals, much nearer tip of snout than base of caudal, the last ray

filamentous, about one-fourth longer than head and nearly reaching base of caudal; the first dorsal ray about 2 in the last one; pectoral 1¼ in head, reaching base of ventrals; ventrals short, reaching only half way to vent, their length 1⅛ in pectorals; anal rays short, base of fin 1⅛ in head; scutes moderate; caudal widely forked, the lower lobe the longer; scales large, thin, deciduous, somewhat crowded anteriorly; accessory scales at bases of pectorals and ventrals; base of caudal with small scales. Color, bluish-black or dark olivaceous on back and sides to level of the jet-black humeral spot; rest of sides and under parts bright silvery; dorsal and caudal dusky; other fins plain.

The cotypes from Grand Plains Bayou are 2 females with ripe roe. They are 4¼ and 5½ inches long, respectively, and differ from the types only in the deeper body and the much darker coloration of the upper parts.

The amount of variation in this species, shown by the material at hand, is exhibited in the following table:

| No. | Head. | Depth. | Eye. | Snout. | Max. | Dorsal. | Anal. | Scutes. | Scales. | Locality. |
|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 4⅛ | 3 | 3⅜ | 5¼ | 3⅜ | I, 12 | I, 24 | 16 + 11 | 40–15 | Grand Plains Bayou, Miss. |
| 2 | 4 | 2⅝ | 3¼ | 5⅛ | 3⅛ | I, 12 | I, 24 | 16 + 11 | 42–15 | Do. |
| 3 | 4 | 3 | 3⅜ | 5⅛ | 3⅜ | I, 12 | I, 24 | 16 + 10 | 42–14 | Melville, La. |
| 4 | 3⅜ | 3⅛ | 3⅛ | 5⅛ | 3⅛ | I, 12 | I, 24 | 17 + 10 | 42–15 | Do. |
| 5 | 3⅜ | 3 | 4 | 5 | 3⅜ | I, 12 | I, 24 | 16 + 11 | 43–15 | Do. |
| 6 | 3⅜ | 3 | 3⅜ | 5⅛ | 3 | I, 12 | I, 24 | 16 + 10 | 41–15 | Grand Plains Bayou, Miss. |
| 7 | 3⅛ | 3 | 3¼ | 5 | 3⅛ | I, 12 | I, 24 | 17 + 9 | 41–15 | Do. |
| 8 | 3⅛ | 3 | 3⅛ | 5 | 3 | I, 12 | I, 24 | 17 + 9 | 41–15 | Black Bayou, Miss. |
| 9 | 3⅛ | 2⅜ | 3⅛ | 5¼ | 3 | I, 12 | I, 24 | 17 + 9 | 40–15 | Do. |

This species appears to be rather common in the larger lowland streams and bayous of Louisiana and Mississippi. It probably does not reach a large size, adult examples being less than 6 inches long. It is not used as food, but is of considerable value as bait in the catfish fishery of the Atchafalaya River and its connecting lakes and bayous.

Etymology, *atchafalayæ*, from the type locality.

**6. Corythroichthys cayorum**, new species. (Pl. 7, fig. 7.)

Type, a male 3½ inches long, No. 48784, U. S. N. M. Cotype, a male, 3¼ inches long, No. 526, U. S. F. C. Type locality, near Crawfish Bar, Key West, Florida, where 3 specimens were obtained, October 19, 1896, by Evermann & Kendall.

Head 8⅜; depth 12⅜; snout 3⅓ in head; eye 4⅓. D. 21 rays, on 1½ + 3½ rings; A. 3, on first caudal ring; C. 10; P. 10. Rings 17 + 26 = 43. Body short and stout; head short, snout very short; tail but little longer than head and trunk. Cranial ridges strong; a high, sharp keel on snout, the occipital keel very high, its edge convex, notched near the middle, not continuous with keel on snout; a strong supraocular ridge, beginning opposite posterior end of nasal keel and continuing backward with one hiatus upon upper edge of opercle; just below this on the opercle another longer but scarcely stronger ridge; another short ridge on anterior part of opercle at level of lower part of eye; opercles very convex, as if swollen outward; keels on body and tail all strong; the 2 lateral keels on body terminating on third caudal ring; the 2 lateral keels on tail beginning on the last body ring, thus overlapping the body keels; median keel on side well developed, terminating on sixteenth body ring; ventral keels strong; abdominal keel very strong. Egg-sac on first 18 caudal rings. Color yellowish-brown, with darker punctulations; tip of snout white; cheek, throat, and under parts of snout white, crossed by about 7 or 8 irregular brownish bars extending downward and backward; opercles brown; fins pale.

This species is related to *C. albirostris* of Heckel, differing from it chiefly in the shorter snout, smaller dorsal, and fewer rings. The genus *Corythroichthys*, established by Kaup in 1856, seems to be well distinguished from *Siphostoma* by the strong keel on the top of the head, the strong opercular ridges, the short, stout body with prominent angles, and the very short snout. As thus defined *Corythroichthys* contains two species besides the one here described, viz, *C. albirostris* Heckel and *C. cayennensis* Sauvage.

Etymology, *cayorum*, of the Keys; from Cayo Hueso, Bone Key, the original Spanish name of the island of Key West.

**7. Cottogaster cheneyi**, new species. (Pl. 8, fig. 8.)

Type, No. 48781, U. S. N. M. Cotypes, No. 48782, U. S. N. M.; No. 527, U. S. F. C.; and No. 5774, L. S. Jr. Univ. Mus. Length of type, 2¼ inches. Type locality, Racket River, Norfolk, New York. Collectors, Barton W. Evermann and Barton A. Bean.

Head 4; depth 6; eye 4 in head; snout 4; maxillary 3½; interorbital width 5½. D. XI–12; A. II, 8; scales 7–56–6. Body rather stout, heavy forward, compressed behind; head heavy; mouth moderate, slightly oblique, lower jaw included, maxillary reaching front of pupil; premaxillaries protractile. Cheeks, opercles, breast, and nape entirely naked; scales of body large and strongly ctenoid; lateral line complete, straight; median line of belly naked anteriorly, with ordinary scales posteriorly. Fins large; dorsals separated by a space equal to half diameter of eye; origin of spinous dorsal a little nearer origin of soft dorsal than tip of snout, its base about equal to length of head; longest dorsal spine 2½ in head, the outline of the fin gently and regularly rounded; soft dorsal higher than spinous portion, the second to tenth rays about equal in length, scarcely 2 in head, the first, eleventh, and twelfth rays but slightly shorter than the others; anal moderate, its origin under base of third dorsal ray, the spines slender, the second a little longer than the first, whose length is 3¼ in head; longest anal rays about 2½ in head; caudal lunate, the lobes more produced and pointed than usual among darters; pectorals long and pointed, the middle rays longest, about 1½ in head, reaching tips of ventrals; ventrals well separated, not nearly reaching vent, the longest rays 1¼ in head.

Color in alcohol, back dark brownish, covered with irregular spots and blotches of darker; side with about 8 or 9 large dark spots lying on the lateral line; belly pale; top of head dark; snout black; lower jaw and throat dark; a broad black line downward from eye to throat; cheek and opercles rusty; spinous dorsal crossed by a median dark line; ventrals blue black; other fins pale, but dusted with rusty specks.

An examination of the 14 cotypes shows some variation in the species. In 2 examples there is a well-developed frenum, rendering the premaxillaries nonprotractile, and in a third specimen the frenum is partially developed; in some individuals the origin of the spinous dorsal is exactly midway between the tip of snout and origin of soft dorsal. The females and immature males are less highly colored than the adult male described above. Length 1¾ to 2¼ inches.

This species is most closely related to *Cottogaster shumardi*, from which it may be readily distinguished by the shorter snout, the naked cheeks and opercles, the smaller soft dorsal, the smaller anal, and the different coloration.

Fifteen examples of this interesting darter were obtained July 18, 1894, by Messrs. Evermann and Bean in the Racket River near Norfolk, St. Lawrence County, New York. It did not seem to be very common, as only 15 examples resulted from numerous hauls of the collecting seine.

Named for Mr. A. Nelson Cheney, State fish-culturist of New York, in recognition of his valuable contributions to our knowledge of the food and game fishes of that State.

**8. Dermatolepis zanclus**, new species. (Pl. 8, fig. 9.)

Type, No. 48843, U. S. N. M.; a specimen 20 inches long to base of caudal fin. Type locality, Key West, Florida, or more definitely, near Dry Rocks Reef, 1 mile east of Sand Key, on rocky bottom in 5 fathoms. Collectors, Evermann & Kendall.

Head 2¾; depth 2$\frac{3}{16}$; eye 8 in head; snout 3½; maxillary 3; mandible 2. D. XI, 19; A. III, 10; scales difficult to count, but about 30–130–35, those above lateral line counted obliquely backward and downward from origin of dorsal, those below from origin of anal upward and forward to lateral line. Branchiostegals 8; gillrakers 8 + 12, short and stout, the longest 1⅔ in orbit.

Body stout, compressed, oblong-elliptical, the dorsal and ventral outlines about equally curved; head moderate, the profile rising from tip of snout to origin of dorsal fin, thence descending in a regular, gentle curve to caudal peduncle; a depression above nostrils and a slight one on nape; interorbital very narrow, equal to orbit; mouth moderate, somewhat oblique; premaxillaries protractile; maxillary broad at tip, reaching vertical at posterior edge of the pupil; supplemental bone well developed; lower anterior edge of maxillary covered by the broad dermal flap of the premaxillary; eye small, high up; nostrils close together and close to eye, the anterior small and round, the posterior oblong-oval, much larger than the other. Small cardiform teeth on each jaw, those in front movable, scarcely canine-like; similar teeth on vomer and a long, narrow band on each palatine. Preopercle coarsely serrate, the serræ short and blunt, more or less obscured by the skin; opercle with a broad dermal border, somewhat produced at lower angle. Fins all large; origin of dorsal slightly in advance of base of pectoral, its distance from tip of snout equal to length of head; third dorsal spine longest, its length about 2¾ in head or 2½ times length of first ray; interspinal membranes of the spinous dorsal deeply

incised, the anterior portion of each somewhat produced beyond its spine; soft dorsal high, the middle rays longest, 1⅔ in head, the anterior portion of the fin gently convex, the posterior slightly concave; pectoral short, broad, and rounded, barely reaching origin of anal, the length 1⅓ in head; ventral pointed, the second and third rays longest, 1⅓ in pectoral, the fin somewhat falcate; anal fin strongly falcate, the fourth and fifth rays longest, longer than pectoral, 1⅓ in head, 2⅓ times length of last anal ray; second anal spine short, 5⅓ in head; caudal shallowly lunate, the lobes 1⅓ in head. Scales small, smooth, and thin, closely but irregularly imbricated; nape, opercles, and cheeks scaled, snout and lower jaw naked; bases of all the fins except the ventrals densely scaled; lateral line beginning at upper angle of opercle, gently arched above pectoral fin, following approximately the curvature of the back and on median line of caudal peduncle.

General color of body in life brown, with large, irregular blotches of dirty white on back and upper part of sides, these blotches with small rusty spots; lower part of sides, belly, and caudal peduncle with irregular whitish spots; belly brassy brown; snout and nape with numerous small, round dark spots; cheek with large blotches of whitish overlaid with black and brassy spots; lips whitish, with dark spots; spinous dorsal blotched with white, olivaceous and black; soft dorsal brown, with numerous white spots and a few black ones, the posterior rays tipped with white and orange; anal olivaceous, with irregular white spots, greenish at edge, the produced rays black toward distal ends; pectoral dark olivaceous, with greenish white splotches, the edge yellowish; ventral rays greenish white, the membranes black; inside of mouth white; eye brown. Related to *D. inermis* (Cuvier & Valenciennes), but differing notably from that species in the shorter, stouter gillrakers, the emarginate caudal, the shorter anal spines, and the strongly falcate anal fin.

Only the type of this species is known. It was obtained by James E. Roberts, a Key West fisherman, October 23, 1896, while fishing in 5 fathoms of water, with hook baited with sardine. Mr. Roberts reports that the fish at first pulled very hard, showing good game qualities, but very soon ceased its struggles and came up a dead weight. This fish was wholly unknown to Mr. Roberts and many other Key West fishermen who saw it. One man claimed to have seen it or a similar fish in the Canaries, which was there known as "cabosa."

Etymology, ζάγκλον, a scythe or sickle, from the falcate anal fin.

**9. Anisotremus surinamensis** (Bloch). *Pompon.* (Pl. 8, fig. 10.)

*Anisotremus surinamensis* Evermann & Bean, Rept. U. S. F. C. 1896, 244.

Not until recently was this species known from the waters of the United States. Its known range extended from Cuba south to Brazil, Surinam being the type locality. On January 23, 1896, a single large example (15 inches long) was obtained at Fort Pierce, Fla., by Messrs. Evermann & Bean. It had been caught in the Indian River near Fort Pierce and was kindly presented to the Commission by Capt. Joseph Smith of that place. No other specimens from our waters were known until in November, 1896, when Dr. Jordan saw a fine example in the French Market at New Orleans. It had been received along with other fish from Eden, Fla., and was doubtless taken in Indian River.

This species is apparently quite rare on the East Florida coast, as the Indian River fishermen to whom we showed our specimen did not recognize it as known to them.

The following is a description of the specimen obtained at Fort Pierce:

Head 3½; depth 2½; eye 4½; snout 2⅔; maxillary 3. D. XII, 16; A. III, 8 or 9; scales 5–50–13. Body deep, back elevated, greatly compressed, profile steep, nearly straight from snout to above eye, a slight depression in front of nostril and another in interorbital space; profile from interorbital space to dorsal strongly arched in a broad curve. Head moderate; cheek deep; mouth rather small; jaws subequal, maxillary barely reaching front of orbit; ventral line of body nearly straight; caudal peduncle moderately long, its least depth equal to snout; teeth in several bands, the outer enlarged and canine-like. Fourth dorsal spine strongest and longest, its length 2⅓ in head; soft dorsal as well as anal, pectorals, ventrals, and caudal densely covered with minute scales; height of longest soft dorsal ray 3 in head; second anal spine very stout, its length equal to that of fourth dorsal spine; third anal spine broad at base, but shorter than second; free edge of soft anal straight; dorsal and anal fins depressible in a scaly sheath; pectoral long and falcate, nearly reaching tip of ventrals, 1⅓ in head; ventral shorter, 1⅓ in pectoral; caudal well forked, the lobes about equal to ventral. Preopercle strongly but irregularly serrate.

Scales of cheek in about 7 rows; those on opercle in about 8 rows; those on interorbital and nape small and crowded; scales of back and sides arranged in oblique rows not parallel with the lateral line; lateral line arched, following approximately the contour of the back. Gillrakers rather short, stiff, 13+19.

Color grayish, darkest on anterior half of body, where each scale is dark brown on its basal half, hen with a white ellipse, the narrow border darker, the contrast between the dark base and the white ellipse very marked; owing to the irregular arrangement of the scales the dark bases in some cases appear as spots; upper side of caudal peduncle brown, sides nearly plain white; snout and under parts of head lilac-brown; under parts of body rusty brown; fins all dark brown, especially the soft parts of dorsal and anal.

**LYOSPHÆRA**, new genus of *Diodontidæ*, allied to *Chilomycterus*.

Type: *Lyosphæra globosa* Evermann & Kendall.

This genus is distinguished from *Chilomycterus* by its armature of flattish, papery or cartilaginous plates to which minute hair-like papillæ are attached. The nostril, as in *Diodon*, is undivided.

Etymology, λύω, to loose, i. e., lax or flabby; σφαῖρα, sphere, ball.

**10. Lyosphæra globosa**, new species. (Pl. 9, figs. 11 and 12.)

Type locality, the Rappahannock River near the mouth of Windmill Creek, Virginia, where 2 specimens were collected by W. C. Kendall, July 18, 1892. Type, No. 48794 U. S. N. M. Associate type locality, Biscayne Bay at Cape Florida, Florida, 1 specimen. Cotype, No. 531 U. S. F. C.

The type specimen is about 1¼ inches long and about 1 inch wide and deep.

Head 3; depth 1½; eye 3½ in head; snout 4; D. 11; A. 4. Form oblong-ovoid; head broad; interorbital space slightly convex, broad, its width 1½ in head. Dorsal and anal far back, each separated from the caudal by a space equal to two-thirds diameter of eye, each very small, the anal rays scarcely distinguishable; pectoral broad and short, with about 20 rays, the length less than interorbital width. Tooth of each jaw solid and continuous. Entire body sparsely covered with minute hair-like appendages or flexible, dermal papillæ, these very short (½ inch in type), and appear to be two-rooted. Nostril a short, entire papilla with two lateral openings and no division at the tip. Ground color yellowish white, this color regularly broken up into hexagonal spots by a network of dark brown, the width of the brown spaces being usually less than one-fourth the diameter of the spots, which are smallest on back and top of head; a villous papilla in the center of each spot.

The two specimens from the Rappahannock agree closely, but the one from Cape Florida, which is a younger individual, differs from them somewhat in color. It may be described as being pale yellowish-white, covered with about 50 narrow dark-brown or blackish rings or circles, each inclosing a circular spot of pale, yellowish-white; these circles smallest on the back and not touching each other anywhere; on the belly they are distant from each other a distance about equal to their own diameter. It seems that as the fish grows older these dark rings approach each other and finally unite to form the reticulations seen in the two other specimens.

We were at first disposed to regard these specimens as being the young of some known species, or possibly *Trichodiodon pilosus*[1] (Mitchill), but an examination of DeKay's figure[2] shows that they can not be Mitchill's species. It is equally apparent that they can not be Cuvier's *Diodon asper*[3] or Günther's *Trichocyclus erinaceus*.[4]

Etymology, *globosus*, spherical.

**11. Lophogobius cyprinoides** (Pallas). (Pl. 9, fig. 13.)

*Gobius cyprinoides* Pallas, Spicilegia, Zool., VIII, 17, pl. 1, fig. 5, 1770, Amboina (?); Poey, Repertorio, I, 335, 1868.

*Lophogobius cyprinoides* Poey, Synopsis, 393, 1868; Poey, Enumeratio, 125, 1876.

*Gobius crista-galli* Valenciennes, in Cuvier & Valenciennes, Hist. Nat. Poiss., XII, 130, 1839, Havana (Coll. Poey); Poey, Repertorio, I, 335, 1868.

One of the most interesting results of the recent investigations of the fish-fauna of the coastal waters of Florida is the finding of this remarkable goby in considerable numbers in the mouth of Little River, near Miami. It is a West Indian species, not hitherto known north of Cuba. The type used by Pallas is said to have come from Amboina, and the specimens which Valenciennes had came from Havana, whence they were sent by Professor Poey. Poey had specimens from Cuba, Haiti, Jamaica, and Santo Domingo.

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[1] *Diodon pilosus*, Mitchill, Trans. Lit. and Philos. Soc., vol. I, 1815, 471, pl. 6, fig. 4.
[2] DeKay, N. Y. Fauna: Fishes, 326, pl. 55, fig. 180, 1842.
[3] *Diodon asper*, Cuvier, Mem. du Muséum, IV, 1818.
[4] Günther, Cat., VII, 316, 1870.

On October 28, 1896, several hauls with a 45-foot fine-meshed seine were made by Messrs. Evermann & Kendall in the Little River at various places in the last half mile of its course, and 35 fine specimens of this species were secured. They were found in all portions of the stream examined, in very brackish water about the mouth, in company with *Neomænis griseus* and *Lagodon rhomboides*, and farther up where the water was perfectly fresh, and associated with such fresh-water fishes as *Notropis*, *Abramis*, *Lucania*, *Jordanella*, *Heterandria*, *Acantharchus*, and *Elassoma*.

In studying the fishes collected in Florida by Dr. H. M. Smith, in 1895, we find 3 specimens of this species which he obtained in Crocodile Hole, Indian Creek, a locality on the opposite side of Biscayne Bay from the mouth of Little River.

Little River flows into Biscayne Bay a short distance north of Miami. It is a short stream, having its rise in the Everglades a few miles to the westward. At the mouth there are a good many mangrove bushes, but farther up the shores are lined with tall marsh grasses. The bottom is composed in most places of hard coral rock, worn into an irregular surface, over which it is difficult to haul a seine. In some places this rock is more even and is overlaid by a thick layer of mud and vegetable débris. The current was slow and the stream was well filled with such water plants as *Myriophyllum*, *Chara*, *Potamogeton*, various species of filamentous algæ, and an occasional patch of pickerel weed (*Pontederia*).

The thirty-five specimens of *Lophogobius cyprinoides* from Little River vary in length from 1 to 1¼ inches. The following description is based upon one of the largest examples:

Head 3½; depth 4; eye 4 in head; snout 4. D. VII–10; A. II, 8; P. 16; scales 27, 9 in a transverse series, counting from origin of anal upward and forward to dorsal.

Head very broad and heavy, its greatest width 1½ in its length; snout short and blunt; mouth large, oblique, maxillary reaching vertical of pupil; teeth in a single series in each jaw, none on vomer or palatines; gill membranes united to the isthmus, the gill slits wholly lateral; branchiostegals 4; jaws subequal; anterior nostril in a short tube; body compressed, tapering from head to the rather long, slender caudal peduncle, which is considerably expanded vertically at base of caudal fin; least depth of caudal peduncle 2½ in head, depth at base of caudal fin 2 in head. Fins all large; origin of spinous dorsal at one-third distance from tip of snout to base of caudal, its base 1½ in head, its longest spine slightly greater than base of fin; the 2 dorsal fins not connected, the interspace very short; base of soft dorsal nearly equal to length of head, the rays all about equal in length, the last reaching base of caudal, 1½ in head; anal fin similar to the soft dorsal, immediately under it, the last rays reaching base of caudal; pectoral broad and long, the length equaling head, reaching past origin of anal; pectorals completely united, the middle rays reaching anal; caudal rounded, the middle rays longest; a high dermal crest from above eye nearly to origin of spinous dorsal, its height about equal to diameter of eye. Scales very large, finely ctenoid; no lateral line; head, nuchal region, and breast naked; cheek and opercles beautifully vermiculated with about 10 irregular lines of close-set mucous tubes.

Color in adult, uniform dark brown, almost black on back and upper part of sides, somewhat paler beneath; fins all black; entire head black.

There is not much variation among the thirty-five specimens. The smaller individuals are somewhat more chunky in general form and the color is lighter. The nuchal dermal crest is present on all.

**OGILBIA** Jordan & Evermann, new genus of *Brotulidæ*, allied to *Dinematichthys*.

Type: *Ogilbia cayorum* Evermann & Kendall.

Body moderately elongate, covered with small, smooth, embedded scales; no lateral line; sides of head with similar scales. Preopercle with its margin adnate, and mucous pores along its border; opercle with a small spine posteriorly; no barbels; jaws subequal; gape of mouth wide, the maxillary broadened posteriorly, but without distinct hook; teeth in jaws in bands, subequal; similar teeth on vomer and palatines; lower lip without cirri. Gill membranes little connected, free from the isthmus; dorsal fin low, continuous, of soft rays only, inserted behind base of pectoral and not joined to the caudal, the base of the fin embedded in thick skin; anal similar to dorsal, but shorter; caudal small, rather pointed; pectorals moderate, inserted high; ventrals inserted before pectorals, each developed as a long filament of two soft rays. Anal papilla of the male without horny appendages or claspers. This genus is closely related to *Dinematichthys*, from which it differs in the absence of horny claspers to the anal papilla. *Dinematichthys ventralis* Gill, from the Pacific coast of Mexico

belongs to it. *Brosmophycis* is also closely related, differing in the presence of cirri on the lower jaw and the absence of developed scales on the side of the head.

Named for J. Douglas Ogilby, the accomplished naturalist of the Museum of Sidney, in recognition of his excellent work on the fishes of Australia.

**12. Ogilbia cayorum**, new species. (Pl. 9, fig. 14.)

Type, No. 48792, U. S. N. M., a young individual 2⅛ inches long. Type locality, Key West, Florida, October 23, 1896. Collectors, Evermann and Kendall.

Head 4; depth 4½; eye 8½ in head; snout 4; D. about 68; A. about 50; scales about 14–87–13; maxillary 1⅓; pectoral 1⅓; ventral 1½; caudal 2½. Body moderately elongate, compressed; head moderate, snout blunt; mouth large; jaws subequal, maxillary extending beyond vertical of eye a distance nearly equal to length of snout; eye very small, high up, situated in anterior third of head; nostril small, close to eye. Teeth small, in bands on jaws, vomer, and palatines. Back elevated, strongly arched from snout to origin of dorsal fin, thence descending in a nearly straight line to base of caudal; ventral outline comparatively straight, slightly concave at front of anal. Dorsal and anal long and low, distinct from caudal, the posterior rays longest, about 3½ in head, base of each scaled; distance from tip of snout to origin of dorsal about 3 in length of body; origin of anal under about 22d dorsal ray, equidistant between tip of snout and base of caudal. Scales very small, embedded, but showing distinctly under a lens; cheek and opercles partially covered with minute, embedded scales; top of head naked; opercle with a large, flat, flexible spine on level with eye. No barbels, cilia, nor tubercles; 2 large mucous pores at symphysis of lower jaw, 2 on preorbital near anterior edge on each side, and a row of 5 or 6 pores on lower jaw and edge of preopercle.

Color, uniform pale olivaceous or light brown, finely punctate with minute brown specks.

A single example of this species was seined on a shoal covered with algæ, at Key West.

Etymology, *cayorum*, of the keys, from Cayo Hueso, Bone Key, the original name of the island of Key West.

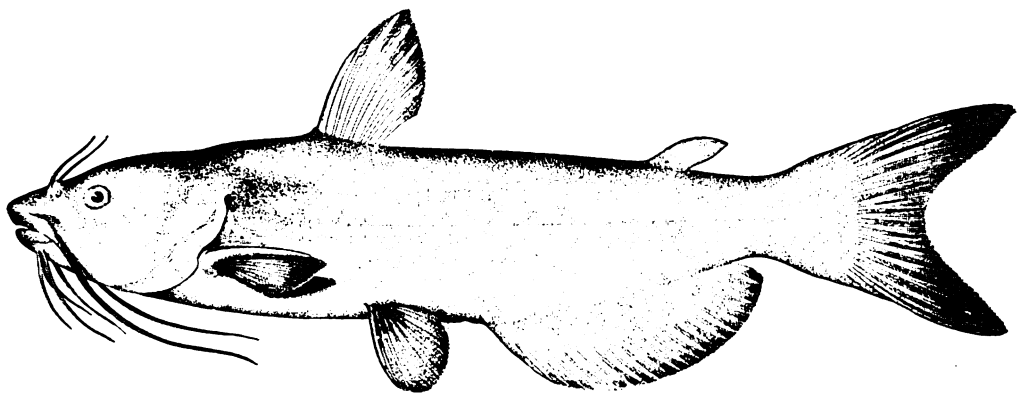

Fig. 1. ICTALURUS ANGUILLA, new species. Type.

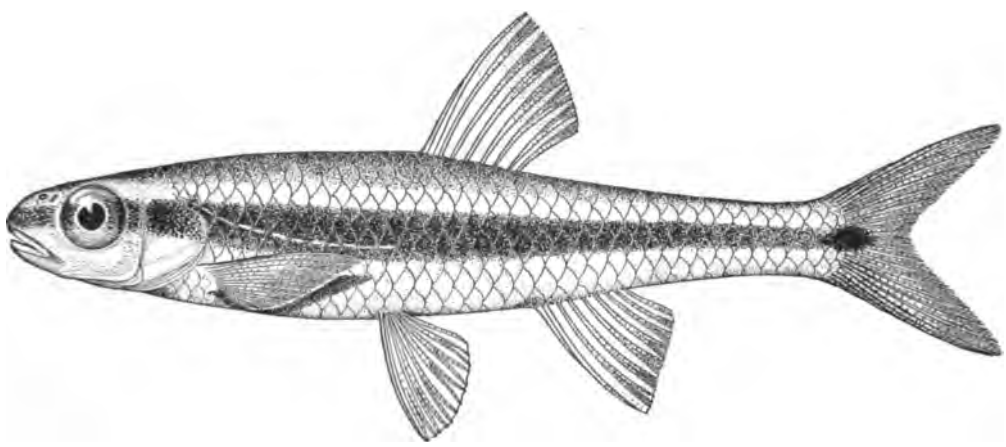

Fig. 2. NOTROPIS WELAKA, new species. Type.

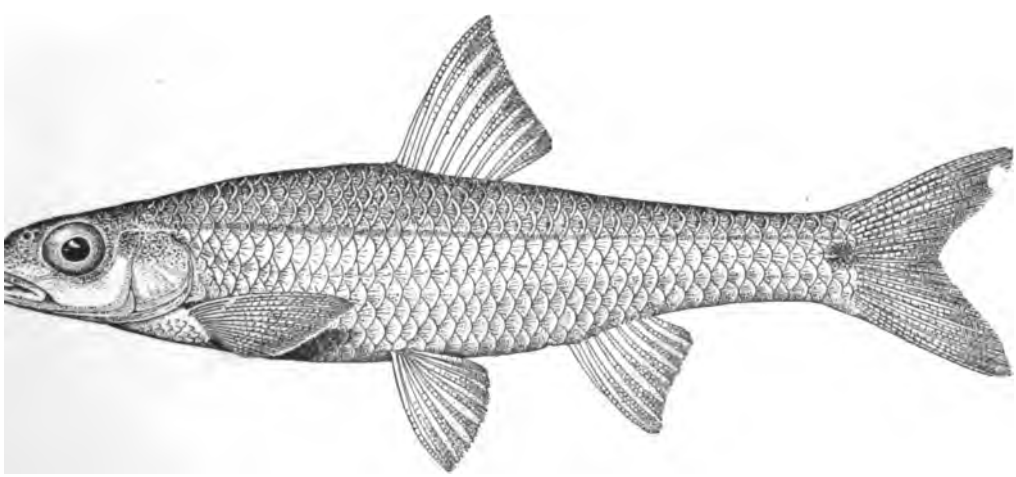

Fig. 3. NOTROPIS HUDSONIUS (DeWitt Clinton).

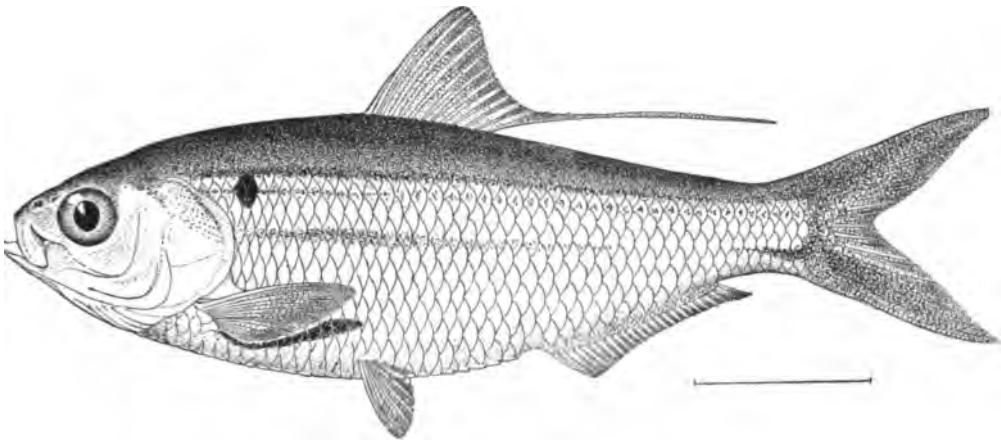

Fig. 4. SIGNALOSA ATCHAFALAYÆ, new species. Type.

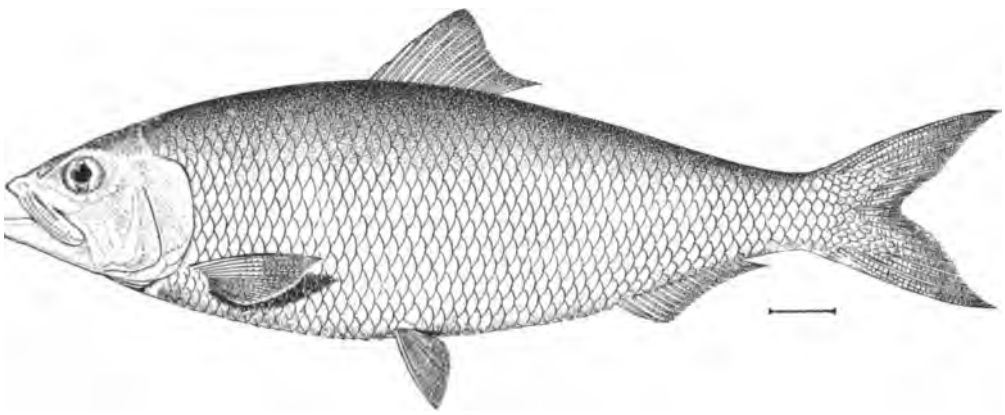

Fig. 5. ALOSA ALABAMÆ Jordan & Evermann. Male; one of the types.

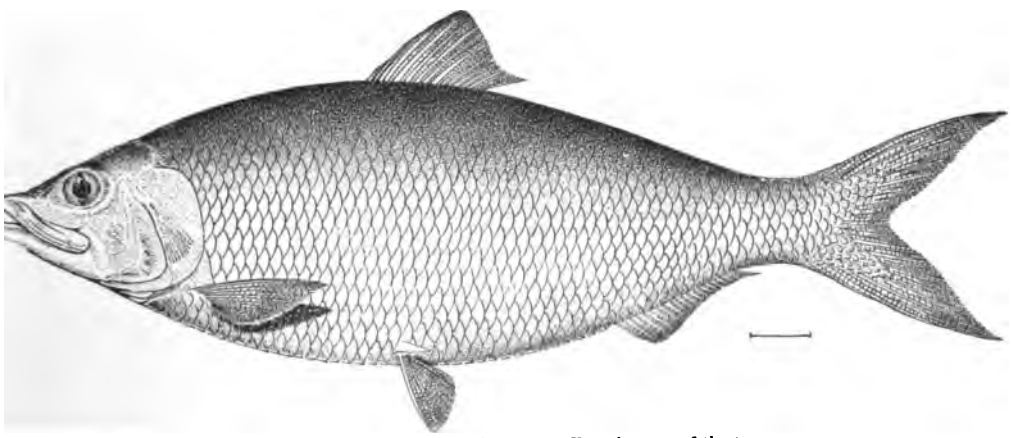

Fig. 6. ALOSA ALABAMÆ Jordan & Evermann. Female; one of the types.

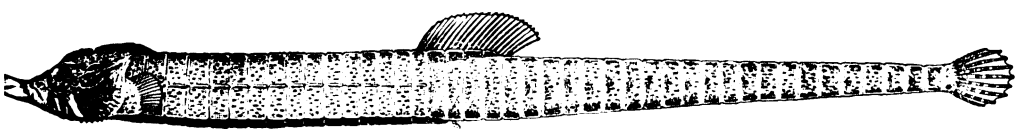

Fig. 7. CORYTHROICHTHYS CAYORUM, new species. Type.

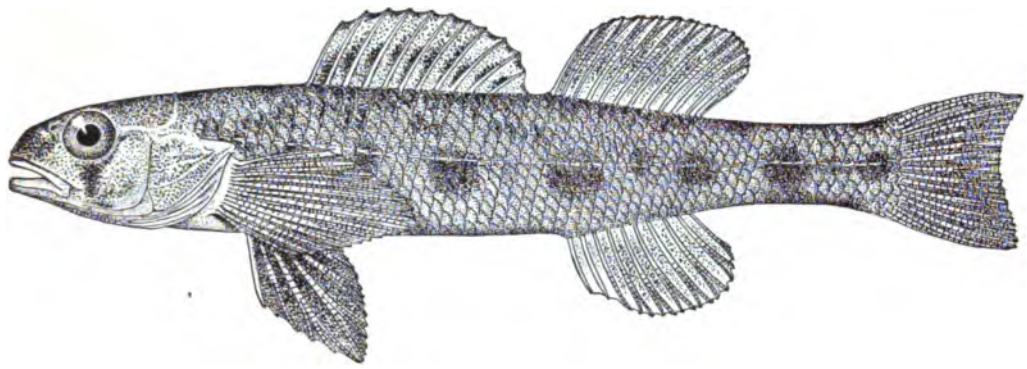

Fig. 8. COTTOGASTER CHENEYI, new species. **Type.**

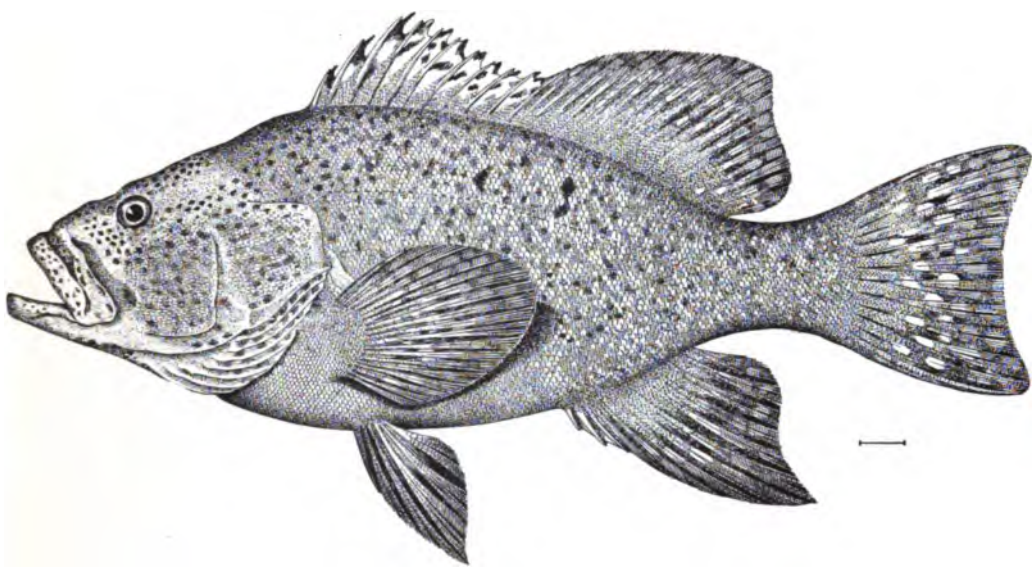

Fig. 9. DERMATOLEPIS ZANCLUS, new species. **Type.**

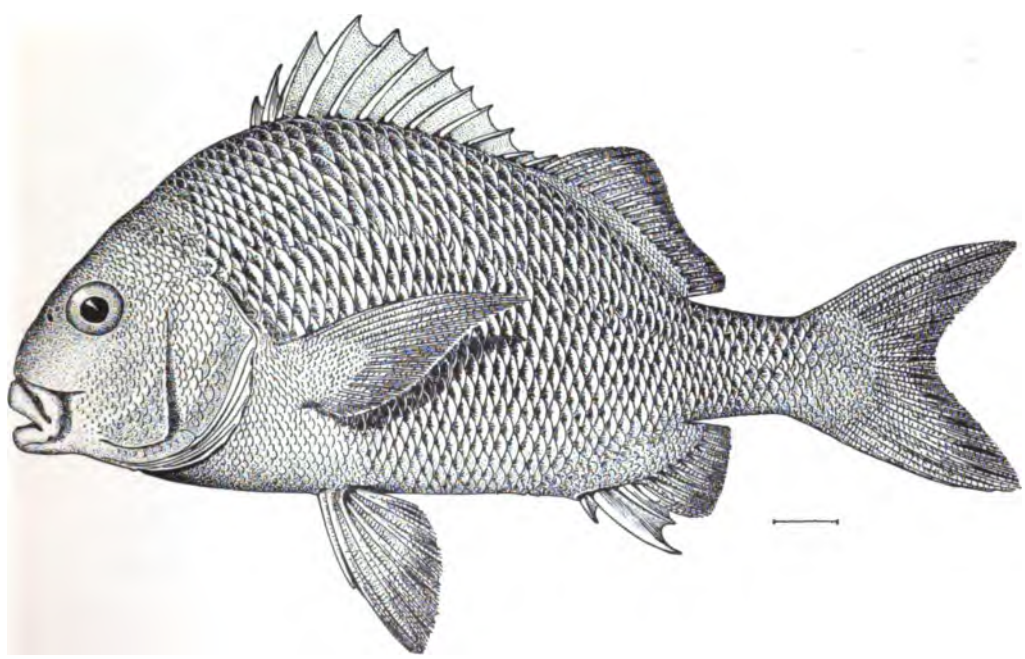

Fig. 10. ANISOTREMUS SURINAMENSIS (Bloch).

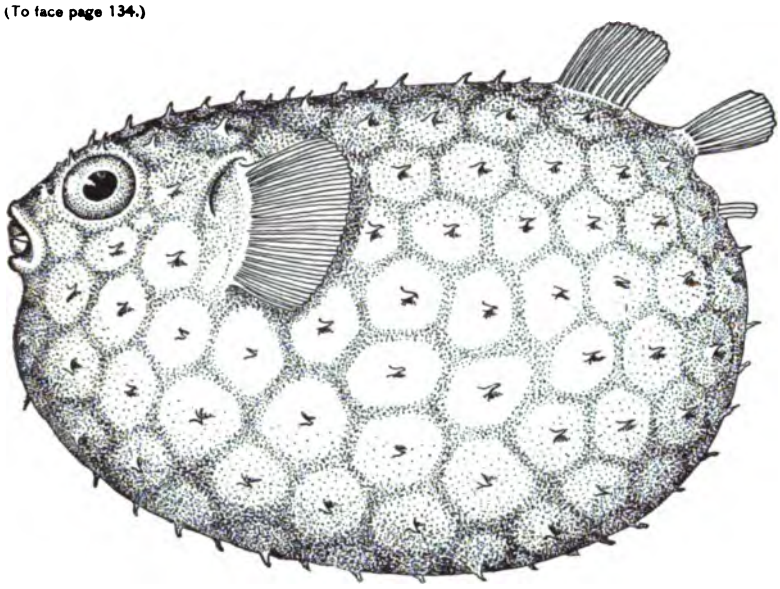

Fig. 11. LYOSPHÆRA GLOBOSA, new species. Type.

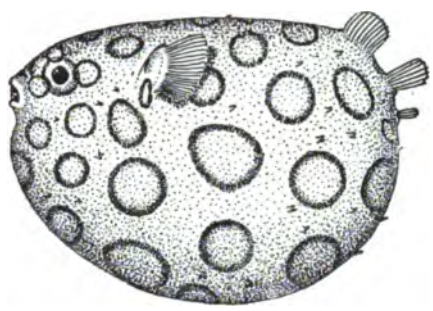

Fig. 12. LYOSPHÆRA GLOBOSA, new species. Cotype; young.

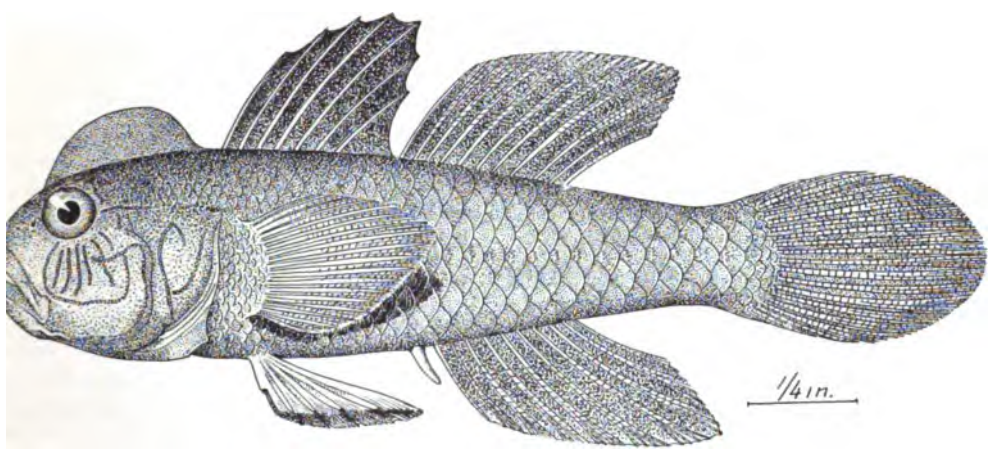


Fig. 13. LOPHOGOBIUS CYPRINOIDES (Pallas).

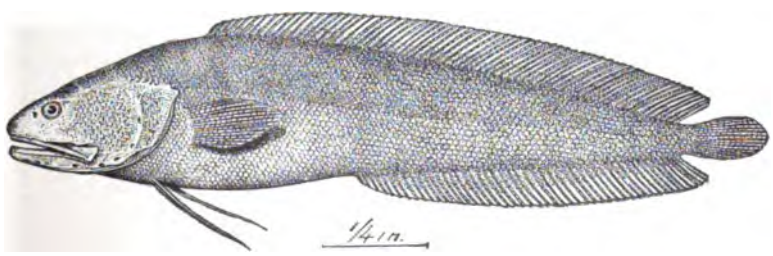


Fig. 14. OGILBIA CAYORUM, new species.

# 6.—THE WORK OF THE UNITED STATES FISH COMMISSION FROM DECEMBER 1, 1896, TO NOVEMBER 3, 1897.

By JOHN J. BRICE,
*United States Commissioner of Fish and Fisheries.*

The following is a summary of the work accomplished by the United States Commission of Fish and Fisheries since December 1, 1896:

At that time the cod-spawning season on the Atlantic coast had just opened, and operations were being conducted, as usual, at the Gloucester and Woods Hole stations, Mass.; auxiliary stations having been established at Kittery Point, Me., and at Duxbury, Mass., for the collection of eggs from fish captured by the commercial fishermen. As a result of the season's operations, 180,000,000 eggs were collected, from which 98,000,000 fry were liberated on the natural spawning-grounds along the coast of Massachusetts. The results secured were 40,000,000 in excess of the previous year. Attention is particularly called to the method adopted of planting the fry on the natural spawning-grounds instead of liberating them in the immediate vicinity of the stations, where less favorable conditions of food, temperature, etc., prevailed.

At the completion of the cod work the propagation of the flatfish (winter flounder) was undertaken at Woods Hole, Mass., on a much larger scale than heretofore, as evidenced by an output of over 64,000,000 of fry from a total collection of 80,000,000 eggs, 69,000,000 in excess of the previous year.

To further extend the propagation of the lobster, the most important crustacean in the waters of the United States, which is now rapidly decreasing in numbers, it was arranged not only to cover the region in the vicinity of Woods Hole and Gloucester, but also to make systematic collections from fishermen operating on the entire coast between Rockland, Me., and Noank, Conn. The schooner *Grampus* was utilized on the Maine coast for the collection of eggs and the liberation of fry; and the steamer *Fish Hawk* was employed as a floating hatchery at Casco Bay. Agents were stationed at Kittery, Me.; Boston, Plymouth, and New Bedford, Mass., and at points in Connecticut, who collected the egg lobsters and held them in live-boxes until called for by launches and vessels from the Gloucester and Woods Hole stations. As a result of this extension of the work, notwithstanding the poor catch, over 128,000,000 eggs were secured, producing 115,000,000 fry; an increase of 20,000,000 over the number obtained the preceding year.

During the spring and summer particular attention was paid to the food, habits, and growth of the young lobster; and much valuable information was obtained at Woods Hole, where extensive experiments were conducted in the holding of the fry during the larval stages. The experiments indicate that, under natural conditions, the young lobster is much less a cannibal than has been believed, eating his fellows

only when natural food is not available. There is reason to doubt whether it lives for the most part at the surface of the water; observations have shown the young as often at the bottom and at the middle depth of the aquarium as at the surface. Reports from various sections along the coast of Massachusetts show that young lobsters are abundant; from ten to twenty, 2 to 4 inches in length, have been frequently found in a single trap. The number caught during the past season is unprecedented, and the abundance is credited to the plants made by this Commission. It is believed that if the work is continued on the same scale as in the past few years this declining fishery will be fully reestablished.

In pursuance of the plan outlined in my previous report, of testing the value for shad propagation of certain rivers along the south Atlantic coast, prior to the establishment of auxiliary hatcheries, careful observations on the movements, food, and growth of the young shad in various streams were made during the winter by scientific assistants. In February and early March the steamer *Fish Hawk* was stationed on the St. Johns River. Later in March the steamer proceeded north to Albemarle Sound, where work was undertaken at the mouth of the Chowan River with such favorable results that over 27,000,000 shad eggs were collected. This, with the collections on the Potomac, Susquehanna, and Delaware rivers, made an aggregate of over 203,000,000 for the season's work, an increase of 55,000,000 over the year preceding. With the establishment of auxiliary stations at a few points along the Atlantic coast there is little doubt, after this year's experience, that the work can be largely increased.

The lake fisheries have also received particular attention; and although, owing to restrictive legislation, the field for the collection of lake trout and whitefish eggs has been confined to Lakes Superior, Erie, and Ontario, a larger collection than in the past is anticipated, as arrangements have been made, in addition to the usual method, to pen several thousand adult whitefish in Lake Erie, with a view to stocking the hatcheries in the upper lakes.

Arrangements have also been made for increasing the production of landlocked salmon by opening an additional station on Grand Lake Stream, Maine. Owing to the partial failure in the catch of Atlantic salmon during the past spring, when the brood fish were collected for the fall work, it is doubtful whether the collection of eggs this year will exceed 3,000,000.

The trout stations in the various sections of the country have made fair collections of eggs, and though the season is not as yet sufficiently advanced for definitely determining the output, there is little doubt that all past seasons will be exceeded. During the spring and fall the usual distributions of yearling bass and crappie were made, and a carload of tautog was sent to the Pacific and planted off the Farallone Islands.

The system of auxiliary stations inaugurated on the Pacific Coast last year, for increasing the output of salmon, has been further extended, so that the collections this season will probably double the phenomenal take of last year. Operations are now being conducted at the Baird, Battle Creek, and Fort Gaston stations, California; on the Clackamas, Rogue, and Salmon Rivers in Oregon, and on the Little White Salmon River in Washington. The results already achieved show the following increased collections:

Clackamas, 6,000,000, against 1,000,000 in 1896.
Little White Salmon, 12,600,000, against 2,125,000 in 1896.
Baird Station, 7,000,000, against 4,000,000 in 1896.

The following table shows the number of eggs of nine of the important species collected during the period under consideration.

| Species. | Annual collections of eggs. | | | Increase over 1895. |
|---|---|---|---|---|
| | 1897. | 1896. | 1895. | |
| Cod | 180,000,000 | 140,000,000 | 140,000,000 | 40,000,000 |
| Flatfish | 80,000,000 | 11,000,000 | 9,263,000 | 70,737,000 |
| Lobsters | 128,000,000 | 105,000,000 | 82,000,000 | 46,000,000 |
| Shad | 203,000,000 | 148,000,000 | 118,000,000 | 85,000,000 |
| Lake trout | *16,000,000 | 16,000,000 | 16,400,000 | ..... |
| Whitefish | *200,000,000 | 125,000,000 | 234,000,000 | ..... |
| Atlantic salmon | *2,800,000 | 2,800,000 | 983,000 | 1,817,000 |
| Landlocked salmon | *1,000,000 | 324,000 | 100,000 | 900,000 |
| Quinnat salmon | *75,000,000 | 37,000,000 | 10,000,000 | 65,000,000 |

* Season not over; number estimated.

The total output of artificially-hatched fishes in the United States at the present time amounts to over one billion annually. This is about five times as great as the combined production of all Europe.

To further test the feasibility of the introduction of quinnat salmon in eastern waters, 5,000,000 eggs were transferred from the Battle Creek Station, California, during the fall of 1896, and as a result 4,000,000 fry were liberated during the past spring in the St. Lawrence, Hudson, and Delaware rivers in New York State, and in the Penobscot and Union rivers in the State of Maine. In addition to these plants, 250,000 fry were retained to rear as yearlings for liberation in the Penobscot River during the present fall.

The acclimatization of the steelhead trout in eastern waters was continued, and as a number of specimens have already been captured in the tributaries of Lake Superior, there is little doubt that this valuable game and food fish will be added to the food supply of this section of the country.

Owing to the wide territory over which distributions are made, it is impracticable, except in a very small proportion of cases, to obtain exact information as to the results secured. Reports are forwarded by agents of the Commission in the field, by correspondents who have been interested in the introduction of fishes in certain waters, and by the State fish commissions, as to the results of plants made under their jurisdiction. From these sources assurance has been received of the successful introduction of the Atlantic salmon in the Hudson and Delaware rivers, numbers of specimens averaging 12 pounds in weight having been captured in New York Bay, while fully 300 were reported to have been taken in the Delaware River during the season of 1895. The rainbow trout, native only to the mountain streams of the Pacific Coast, has been successfully acclimatized in nearly every State east of the Rocky Mountains. Reports from all sections of the country indicate the successful establishment of the large-mouth black bass in streams hitherto unoccupied by them. An introduction of both species of the crappie into the Potomac River has resulted from a small plant made by this Commission in 1894. As an indication of their abundance, it may be stated that 4,000 crappie, weighing between ½ and 2 pounds, were removed from the Chesapeake and Ohio Canal during the month of March and liberated in the Potomac. Considerable numbers have also been taken in the vicinity of Analostan Island, near the mouth of Little River, opposite Washington, D. C.

The scientific work of the Commission has an important bearing on the artificial increase of food-fishes, and is carried on with a view to determine the best methods to be pursued in fish-culture, to ascertain the results of fish propagation, and to study the habits, migrations, growth, food, enemies, and diseases of fishes.

The recent marked development of the fisheries of the southern California coast makes it desirable that the extent, location, and resources of the principal fishing-banks be accurately determined. Accordingly, in the spring of 1897 the steamer *Albatross* conducted preliminary investigations on parts of that coast, having for their special object the pointing out of the possibilities for an extension of the offshore fisheries. This work will be continued until the fishing-grounds of the coast are thoroughly surveyed.

In the summer of 1897, the *Albatross* entered on an examination of the salmon streams of Alaska. No systematic study of the salmon in different parts of this Territory has heretofore been undertaken, and important results are expected from the researches begun this season. The very active prosecution of the fisheries in certain streams threatens to seriously reduce the supply unless effective measures are taken to overcome the destruction. The conditions are so various along the 3,000 miles of the Alaskan coast on which the salmon fishing is done that no general protective law can be framed that will apply to all regions; the determination of the proper restrictive measures for the different streams thus becomes an important matter. The inquiries progressed very satisfactorily this season and will be resumed next year.

Extended surveys of the streams and lakes in the Pacific States have been in progress, having for their object the study of the abundance, spawning habits, and spawning-grounds of the salmon and other fishes, and the examination of available sites for hatcheries.

In conjunction with the efforts to increase the mackerel supply on the New England coast by artificial propagation, important studies were conducted relative to the development of the mackerel egg and its natural distribution at the surface of the ocean by winds and tides.

At Woods Hole, Mass., the Commission has, in addition to the hatchery, a laboratory and a large, well-equipped residence building erected for the accommodation of those who are allowed the privilege of the laboratory for scientific research. During the past summer there was begun the organization of a corps of trained scientific experts who, under the direction of the chief of the Division of Scientific Inquiry of the Commission, should pursue a concerted line of research bearing directly on the habits and life-history of the commercial fishes and pertinent to the practical work of the Commission. This plan promises to be very successful, and it is believed will give to the Government a practical biological institution of great value.

Canvasses of the commercial fisheries in their statistical and other aspects have been carried on throughout the country. In order that this information may be accurately obtained and made promptly available, a plan has been adopted of locating statistical agents of the Commission at important centers where each can give attention to a certain district. From the reports received from these agents special bulletins relating to the conditions of the fishery industries are issued to those engaged in the business and to the various boards of trade, and in a like manner monthly bulletins are issued, giving the quantity and value of the catch landed at certain important

ports. This system has received general commendation, and will be extended to embrace all centers of the fishing trade. At the end of each year these statistics will be issued in complete form, and comprehensive and reliable data will be thus at once made available.

In the general deficiency bill approved July, 1897, $4,216 was appropriated for the completion of the Manchester, Iowa, station; $1,800 for the San Marcos, Texas, station; $2,500 for the construction of a dwelling at the St. Johnsbury, Vermont, station; also $10,000 for rebuilding the cars Nos. 1 and 3, and $500 for the investigation and selection of a fish-cultural station in the State of Georgia. The Manchester station has been completed and thoroughly equipped, and is ready for operation. The necessary improvements have been made at the San Marcos station, and work at St. Johnsbury on the superintendent's residence is now in progress. Cars Nos. 1 and 3 have been thoroughly rebuilt and refitted with all modern appliances. A careful investigation has also been made of a number of available sites recommended for a fish-cultural station in the State of Georgia, and a full report thereon will be submitted to Congress. Further investigations with reference to the selection of a fish-cultural site in the State of New Hampshire, authorized by act approved March 2, 1895, have been made and a site selected. As soon as the property has been acquired the construction of the station will be undertaken as appropriated for in the sundry civil bill approved June 4, 1897.

An appropriation of $10,000 for the establishment of a fish-cultural station in the State of South Dakota having been made on June 30, 1896, an examination of localities favorably considered by my predecessor was commenced in December, 1896. A site at Spearfish was favorably reported upon; but as this examination had been conducted during the winter months it was determined, before a final decision was reached, to make further investigation during the following summer. This resulted in the selection of Spearfish, and steps have been taken to acquire the property. As soon as the titles have been passed upon by the Attorney-General the construction of the station will be commenced.

The station provided for in the State of Tennessee, by act approved August 18, 1894, was located in Unicoi County, near Erwin, after an examination of numerous sites throughout the State. The hatchery, residence, and outbuildings have all been constructed and the ponds are partially complete. Arrangements are being made to collect the necessary brood fish, and the station will be in operation by the close of November 3.

U. S. COMMISSION OF FISH AND FISHERIES,
*Washington, D. C., November 3, 1897.*

# 7.—NOTES ON THE HALIBUT FISHERY OF THE NORTHWEST COAST IN 1895.

By A. B. ALEXANDER, *Fishery Expert, Steamer Albatross.*

The halibut fishery of the northwest coast has developed into an industry of considerable importance, there being double the number of vessels engaged in it that there were four years ago. The demand for this fish five years ago was mostly limited to local orders; now large shipments are made to all parts of the West. For the past two winters important shipments have been made to the Atlantic Coast by Canadian fishermen. The American catch finds a market in the States west of the Mississippi River. There being less demand for halibut in summer, the Canadian vessels continue in the fishery only a part of the year.

In 1890 there were landed at various points on Puget Sound 740,000 pounds of halibut, valued at $16,750. In 1891 the amount increased to 994,000 pounds, valued at $23,620, and in 1892 to 1,410,000 pounds, representing a value of $29,140. The amount caught continues to increase yearly. From estimates made by wholesale dealers and fishermen it is safe to say that about 2,500,000 pounds were landed in Puget Sound in 1895. Two-thirds of this amount were taken in northern waters on banks off Cape Scott, Vancouver Island, Rose Point, and North Island, which lie off the northern end of Queen Charlotte Island.

For several winters past, one and sometimes two steam vessels have fished for halibut on the northern banks, sailing from Vancouver, British Columbia. At first the enterprise was not very successful, owing to the limited demand for halibut and also to the inexperience of the fishermen. But it did not take long to find the best fishing-grounds, and much valuable time was thus saved. The success of these vessels caused dealers and fishermen of the East to become interested, and soon their capital was invested, and in the winter of 1895–96 three steam vessels were fishing for halibut on the northern banks. Two sailed from Vancouver and one from Victoria. At Vancouver the fishery is under the management of Americans and is controlled by American capital. It is estimated that the catch of these vessels was nearly half that of the American fleet, or about 1,000,000 pounds, nearly all of which was exported to the United States. Fish landed at Victoria was shipped to Tacoma; that which came into Vancouver was shipped east over the Canadian Pacific Railroad, and distributed over the Eastern States.

When this fishery began on the Pacific Coast, Port Townsend was its center, on account of having better harbor accommodations than most places on Puget Sound, but for the past few years Tacoma and Seattle, chiefly the latter, have absorbed the business. This was brought about by their having much better shipping facilities and a larger population. Now only an occasional fare is landed at Port Townsend. At one time there were three wholesale and retail fish-dealers here, but during the past year there has been only one.

Nearly all the halibut caught on local banks and in northern waters by American fishermen is landed at Seattle and Tacoma. Fairhaven and Whatcom, during the past two years, have made shipments of halibut, but only in a small way as compared with Seattle; herring, smelts, and salmon are the fish mostly shipped from this northern part of Puget Sound This industry has increased 50 per cent in the past year.

In 1895 there were 48 small boats sailing from Port Townsend, Seattle, and other places on Puget Sound engaged in this fishery. These boats ranged in size from 5 to 10 tons; most of them were sloops, but a few were schooners. They carry a crew of 2 to 4 men. The smallest confine their fishing to the banks off Cape Flattery and in the Straits of Fuca. A few of the larger boats make occasional trips to Cape Scott and the Queen Charlotte Islands.

In addition to the small boats there is a fleet of 10 larger ones, ranging from 18 to 40 tons, averaging about 25 tons. Most of these are schooner-rigged and were built for the halibut fishery. This style of craft is the outgrowth of the small boats first used. As more northern waters were sought, it was found that boats under 10 tons were too small either for comfort or safety. They can be run economically, but the amount they carry is too small for the voyage to be remunerative. A few fishermen have talked of introducing sailing vessels of from 75 to 100 tons in this fishery, similar to those employed on the Atlantic Coast. Such vessels would be very expensive, and it is claimed that they would be less profitable than the vessels now employed. The banks on this coast not being so large as those on the Atlantic, a fleet of 10 or 12 large vessels fishing in one locality would soon temporarily exhaust the supply, and considerable time would be lost in searching for new grounds. The experience of the past few years shows that vessels of from 30 to 40 tons are best suited for the halibut fishery on the Pacific Coast, and are the type most likely to be used in the future.

In spring most of the small boats and some of the large ones fish on Flattery Bank and adjacent grounds. As the season advances halibut in this region grow scarce and better fishing is found on local "spots" in the Straits of Fuca. During the spring and summer months good fishing is found on small banks off the San Juan Islands and in the vicinity of Port Townsend.

As the halibut fishery has increased, fishermen have been searching for new grounds. The first ground of any importance discovered north of Cape Flattery Bank was in the vicinity of Cape Scott, on the northern end of Vancouver Island. Halibut were found here in considerable numbers and it was thought that the ground covered a large area, but it was soon learned that the bank was small and the best localities confined to small patches, found only by landmarks. On these places fish are sometimes very abundant, but no extensive fishing can be carried on. A fleet of vessels would soon exhaust the supply. Fishermen say that halibut on this ground are now very scarce as compared with two years ago.

The character of the bottom on the Cape Scott ground is rocky. The weather here at times is very stormy, making fishing very difficult. Foggy weather prevails for many days at a time, and at such times when fish are scarce in one place it is not easy to find another ground, owing to the landmarks being hidden from view.

On several occasions halibut on this ground have suddenly disappeared, and on investigation they were found on the north side of Hecate Strait, in the vicinity of Provost Island. It was reported that a prolific ground was off Lyall Island, from 5 to 8 miles off shore, but only small catches have been taken there.

One of the best grounds yet discovered lies off the northern end of Graham Island, between Rose Point and North Island. All along this shore, a distance of 60 miles, good fishing is found in from 25 to 40 fathoms of water. The bottom is chiefly sand. Fish are found here in considerable numbers at all seasons, but they are more abundant in the winter and fall months.

From Rose Point southward below Cape Fife nearly to White Cliffs, a distance of nearly 30 miles, halibut are abundant. The bottom is sandy, and the water very shallow, from 4 to 5 fathoms being the depth where the most fish are taken. Vessels on this ground are frequently in a dangerous position, there being many bars and shoals not located on the chart. When fishing off the northern end of Graham Island, the only shelter to be had when a gale suddenly comes on from the northwest is under the southeast side of Rose Point. If vessels are fishing on this side of the island, and the wind increases fresh from the eastward, they are compelled to seek shelter on the west side of Rose Point. When the wind blows here with any great force, the sea becomes very rough. Fishermen say that it is a dangerous locality, and those not thoroughly acquainted should give it a wide berth.

Across Dixon Entrance, on the south side of Prince of Wales Island, in the vicinity of Nicholas Bay and Cape Chacon, a few schooners have taken good fares. Here, as at Cape Scott, the ground is made up of small "spots," which can only be located by landmarks. Only a few vessels can fish on this ground; it is said that even a small fleet would soon exhaust the ground, not permanently, but for some weeks. The Indians of this locality catch halibut here in considerable numbers, and from these people the white fishermen soon learn the best places.

The best banks, so far as discovered, are in the Canadian waters; few places in southeastern Alaska have been found where halibut are in such abundance as on the above-mentioned grounds.

Canadian vessels fish mostly on grounds off Banks, Goschen, and Stephens islands, which lie on the east side of Hecate Strait. The bottom is composed of sand, shells, and patches of rock, with a depth of water varying from 6 to 35 fathoms. A bank makes off from the Warrior and Seal Rocks and extends nearly across the Strait to Cape Fife.

From the northern end of Banks Island to Shrub Island on the south, and also off Goschen and Stephens islands, halibut are abundant during the winter months.

Around the Gardner Islands, which lie 32 miles SE. by E. from Banks Island, is a good fishing-ground. In the winter of 1895, 90,000 pounds of halibut were caught there by one vessel in three days. About 12 miles S. $\frac{3}{4}$ W. from the southern end of Gardner Islands is a small bank covered by 14 fathoms of water, where at seasons halibut are found in abundance; several trips have been taken here.

Sixty miles farther south from the last place mentioned is a small bank off the north side of Hecate Island. Indians of this region fish with set lines. Few white fishermen have ever taken halibut here, though Indians catch considerable quantities near Killisnoo; but the ground is not large enough to induce a fleet of vessels to fish on it. In many places around Prince of Wales Island halibut are plentiful, but there are no extensive banks.

Halibut on the northern banks are sometimes very erratic; in places where they are numerous one day few will be found the next. It frequently happens that a vessel will have good success for several days and in a few hours' time fish will

become so scarce that it is useless to remain longer on the ground. Fishermen can give no cause for this sudden disappearance other than that the halibut are traveling in schools, going from one bank to another, not stopping long at any one place.

On all the grounds halibut are more plentiful in winter than in summer, and are scarcer in June than at any other time in the year. At this season they begin to scatter all through the numerous bays and channels of British Columbia and southeastern Alaska. At places where salmon canneries are located, halibut in considerable numbers are seen feeding on the offal that is thrown away. In the fall months fewer halibut are found among the islands; it is then that they seek more remote localities.

Fishermen say that on banks composed of rock, sand, and gravel bottom the food of halibut is largely sand-lance. In the vicinity of Rose Point their food is mostly crabs, the bottom being thickly covered with that species. It is said that on ground where red rockfish are plentiful few halibut may be looked for.

Herring, both fresh and salt, is the bait principally used for catching halibut. Boats sailing from Puget Sound ports lay in a supply before starting out on a voyage. It is generally kept on ice, although sometimes a quantity is salted. Considerable salt herring is used by the Canadian vessels. When on the fishing-grounds the trawls usually take large quantities of small fish of various species, which are not marketable; these are also used for bait. Halibut, not being very particular as to what kind of bait is presented to them, it is not at all difficult to satisfy their appetite. Dogfish, with the skin removed, makes a very good bait; good catches have been taken with it.

The price of halibut on this coast does not fluctuate in the same manner as it does in the East. While it sometimes suddenly rises 4 and 5 cents a pound, it seldom goes above 10 cents a pound. The average price for 1895 and 1896 was from $2\frac{3}{4}$ to 3 cents a pound. During the month of June several trips were sold for a cent a pound. A trip of 20,000 pounds lay in the harbor of Seattle a week without receiving an offer, the fish being finally taken to Tacoma and sold for a cent a pound. As a rule the supply of halibut exceeds the demand, keeping the price at a low figure.

Halibut caught on Flattery Bank average about 18 pounds; those taken on grounds in the Straits of Fuca run about 25 pounds. Fish from the Straits are better in quality than those from the offshore grounds. The northern halibut are still larger than those in the Straits of Fuca; they average fully 30 pounds, and occasionally individuals weighing 175 and 200 pounds are caught. As a rule, fish of this size are inferior in quality, and many of them are not considered worth saving at all.

Frequently among the large halibut gray ones will be found, but few of this color are found among small fish.

An occasional trip of fletched halibut is caught on the northern banks, but this branch of the fishery has never been carried on very extensively, owing largely to the light demand for smoked halibut on the Pacific Coast. A number of carloads of fresh halibut shipped east that did not meet with ready sale have been fletched and smoked. Fletches from northern halibut are of good quality, but those from halibut caught in the vicinity of Cape Flattery are not considered so good.

# PROCEEDINGS AND PAPERS

OF THE

# NATIONAL FISHERY CONGRESS,

HELD AT

TAMPA, FLORIDA, JANUARY 19-24, 1898.

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# PREFATORY NOTE.

U. S. COMMISSION OF FISH AND FISHERIES,
*Washington, D. C., February 23, 1898.*

The National Fishery Congress, which convened at Tampa, Florida, in January, 1898, pursuant to the call of the governor of Florida, was attended by a large number of persons prominently connected with the fisheries, fish-cultural work, scientific research, and general economic pursuits from all parts of the United States. Papers covering a wide range of subjects were presented, and some of them evoked considerable discussion. A number of special topics of timely importance were brought up, some of which formed the basis for formal resolutions. Of scarcely less consequence than the regular proceedings of the Congress was the opportunity afforded the delegates for the personal interchange of opinions and experiences.

In order that a permanent record may be made of the work of the Congress, the Commission has undertaken the publication of the papers and an abstract of the proceedings, but in so doing assumes no responsibility for any opinions expressed.

For the purpose of expediting the issuance of this report, it has been deemed advisable to utilize the Bulletin for 1897, although the proceedings more properly belong in the Bulletin for 1898, the printing of which will not begin for some months.

GEORGE M. BOWERS,
*Commissioner.*

# 8.—PROCEEDINGS OF THE NATIONAL FISHERY CONGRESS, HELD AT TAMPA, FLORIDA, JANUARY 19-24, 1898.

WEDNESDAY, *January 19.*

The convention met at noon in the casino of the Tampa Bay Hotel and was called to order by Hon. M. E. Gillett, mayor of Tampa.

On motion of Hon. S. G. McLendon, of Georgia, Mr. Gillett was made temporary chairman, and on motion of Maj. A. A. Wiley, of Alabama, Mr. H. Cunningham, secretary of the Tampa Board of Trade, was elected temporary secretary.

On motion of Mr. William E. Meehan, of Pennsylvania, the chair appointed the following committee on credentials and permanent organization, the chairman being subsequently added to the committee: Mr. W. E. Meehan, of Pennsylvania, chairman; Hon. S. G. McLendon, of Georgia; Maj. A. A. Wiley, of Alabama; Dr. H. M. Smith, of Washington; Mr. F. Q. Brown, of Massachusetts, and Gen. Patrick Houston, of Florida.

On motion of Major Wiley the following resolution was adopted:

*Resolved*, That no resolution will be considered by this Congress that is not germane to the call of Governor Bloxham, and that all resolutions shall be referred, without debate, to the committee on resolutions, when duly raised by this Congress.

The chairman announced that it was expected that at this morning's session Governor Bloxham would deliver an address of welcome and that the work of the convention would begin, but owing to the fact that a great many delegates, who expected to be here, were en route and would arrive on incoming trains, it was thought best to defer further action until to-morrow.

The Congress then adjourned until 11 o'clock a. m., January 20.

THURSDAY, *January 20.*

The Congress was called to order by Temporary Chairman Gillett. The secretary then read the following call of Governor Bloxham for the Congress:

EXECUTIVE MANSION, *Tallahassee, Fla., April 14, 1897.*

Impressed with the importance of propagating and protecting the fish in the waters of the United States, and the necessity of devising means and formulating methods to save from total extinction many varieties of valuable food-fish, we have deemed it proper to issue a call for a National Fishery Congress to assemble at Tampa, Fla., on the 19th day of January, 1898.

The National Fishery Commission of the United States will take a prominent part in the proceedings of this assembly.

We respectfully request the governors of the various States of the Union, and the fishery commissioners of the same, to appoint delegates to this Congress, which should command the earnest

attention of all good citizens of the United States. In this interest we commend the words of Hon. T. T. Wright, who says:

"The water farms of the United States, oceans, lakes, and rivers, are neglected and but half developed. Let us turn on them the search-light of science to reveal their treasures and possibilities, and thereby increase openings for new fields of labor and a larger supply of food for mankind."

Trusting that this Congress will receive the consideration it deserves, and that its deliberations may prove beneficial to the citizens of the United States and the world at large,

W. D. BLOXHAM,
*Governor of Florida.*

**Mr. Gillett then addressed the meeting, welcoming the delegates in behalf of the city of Tampa, after which he introduced Governor Bloxham, who spoke as follows:**

The assembling of this Fishery Congress is the result of the suggestion of Col. T. T. Wright, one of the most progressive intellects of the South. His presentation of the possibilities of such a meeting was the prompting cause of my issuing the call, and he organized the movement so well executed by Tampa's board of trade and Dr. H. M. Smith of the United States Commission of Fish and Fisheries. Tampa's representative will bid you welcome to this city; and I have been requested to welcome you not only to this progressive and prosperous city, but to Florida. I take pleasure in performing the task, feeling that in doing so I but voice the sentiments of our entire people.

I welcome you to a State whose history is the most romantic in the annals of America. When familiar with the raiment with which nature has clothed her—the richest that a tropical luxuriance could furnish so captivating a figure—with her limpid streams glistening like sheens of silver under a semitropical sun; with deep-bedded rocks reflecting with a dazzling brilliancy God's great orb of light, and penciled fringings of the richest foliage adding a halo to their unsurpassed beauty, can we wonder that fable's persuasive tongue invested her with treasures surpassing the famed El Dorado? Are we surprised that imagination's "weird sisters" pictured her waters as holding by divine right the most precious of Hygeia's elixir to restore honorable but tottering infirmities to the freshness and vigor of robust manhood, and that the hope of this famed fabled physical regeneration should have served as an irresistible stimulant to Spain's lion-hearted cavalier, Ponce de Leon?

You meet here upon historic ground, where the footprints of some of Spain's greatest cavaliers and America's noblest captains can be traced. While it is not my intention to recur to their heroic deeds, or to offer you a cup filled with the ambrosia of ancient story, yet there is one romance, based upon historic fact, associated with this very spot, that I feel you will kindly indulge should a brief reference thereto be made.

Wherever the history of America is read, there the story of Pocahontas is known. The romance is most captivating, and some of Virginia's most honored sons trace back a lineage to this daughter of the forest. But the historic fact that a similar scene was enacted on this very spot, three-quarters of a century before the name of Pocahontas was ever lisped by English lips, is unknown even to many Floridians.

It was here, in 1528, twelve years before De Soto landed upon Tampa's Bay, that Juan Ortez, a Spanish youth of eighteen, having been captured at Clearwater, was brought before Hirrihugua, the stern Indian chief, in whose breast was rankling a vengeance born of ill treatment of his mother by the followers of the ill-fated Narvaez. Ortez was young and fair, but the cruel chief had given orders, and here was erected a gridiron of poles, faggots were prepared, and young Ortez was bound and stretched to meet the demands for a human sacrifice. The torch was being applied, the crackling flames began to gather strength for a human holocaust, when the stern chief's daughter threw herself at her father's feet and interposed in Ortez's behalf. Her beauty rivaled that of the historic dame "whose heavenly charms kept Troy and Greece ten years in arms." The soft language of her soul flowed from her never-silent eyes as she looked up through her tears of sympathy, imploring the life of the young Spaniard. Those tears, the ever-ready weapon of a woman's weakness, touched the heart of even the savage chief, and Ortez was for a time spared.

But the demon of evil in a few months again took possession of Hirrihugua, and his daughter saw that even her entreaties would be unavailing. She was betrothed to Mucoso, the young chief of a neighboring tribe. Their love had been plighted—that God-given love that rules the savage breast as—

"It rules the court, the camp, the grove,
And men below, and saints above."

Her loving heart told her that Ortez would be safe in Mucoso's keeping. At the dead hour of night she accompanied him beyond danger, and placed in his hands such tokens as Mucoso would recognize. She acted none too soon. As the sun rose over this spot its rays fell upon the maddened chief, calling in vain for the intended victim of his revenge. His rage was such that it dried up the wellsprings of parental affection, and he refused the marriage of his daughter unless Ortez was surrendered. But that Indian girl, although it broke the heartstrings of hope, sacrificed her love to humanity; and Mucoso sacrificed his bride upon the altar of honor. Ortez lived to welcome De Soto.

Tell me, aye, tell the world, where a brighter example of noble virtue was ever recorded. Where in history do you find more genuine and more touching illustrations of "love, charity, and forgiveness"—the very trinity of earthly virtues and the brightest jewels of the Christian heaven? What a captivating theme this Florida Pocahontas should present to the pen of imagination picturing this spot, then and to-day associated with romance rich in historic lore!

But I am here to welcome you to this National Fisheries Congress; and what location more fitting for such a congress than the shores of this western Mediterranean, the Gulf of Mexico.

Mathew Maury, that great intellect and writer on the currents of the oceans, that great map-maker of the air that circles above Old Ocean's waves, states it as a physico-commercial fact that "the area of all the valleys which are drained by the rivers of Europe that empty into the Atlantic, of all the valleys that are drained by the rivers of Asia that empty into the Indian Ocean, of all the valleys that are drained by the rivers of Africa and Europe that empty into the Mediterranean, does not cover an extent of territory as great or as fertile as that included in the valleys drained by the American rivers alone, which discharge themselves into this our central sea."

Those vast valleys furnish waste organic matter that is brought into this inland sea, furnishing abundant food for animal life. The temperature of the waters of the Gulf of Mexico and the Caribbean Sea is most favorable to the development of the lower orders of animal life; and the animalcula and small fish feed upon this abundant supply of food, and in turn become food for larger fish. The Gulf Stream, originating in the Caribbean Sea, sweeping through the Gulf of Mexico and around the entire coast of Florida, helps to bring to our very doors this vast food supply, and gives us the best of feeding-grounds, many times the area of our State.

What State, then, more suitable in which to organize a national fishery congress than Florida? Stimulated by the erroneous sentiment that America's fishery resources, on account of the great area and capabilities of her waters, are practically inexhaustible, improvidence has led, in many States, to useless and wasteful destruction that tends strongly to the depletion of their waters.

The valleys drained into the Gulf of Mexico and the Caribbean Sea range through all the producing latitudes of the world and embrace every agricultural climate under the sun. Upon their green bosom rests the throne of the vegetable kingdom; and in the near future, when the waters of the Atlantic and Pacific shall be allowed to commingle through a canal across Central America, the commerce of the world will here hold its court.

Public sentiment is becoming largely directed and educated up to a full comprehension of the importance of the industry, and the General Government is lending its powerful aid to the dissemination of information and the propagation of valuable species of food-fish. With such earnest and intelligent workers as are now in the Government employ and at the head of this great work, with the various States cooperating, we may confidently look to a cessation of useless improvidence and an increase in the supply of desirable food-producing fish. And what efforts more commanding and deserving greater consideration than the suggesting of new fields of labor looking to increasing the food supply of mankind? And where can we look more confidently for such increase than in the water farms of America?

This Congress is really in the interest of the highest civilization, for no questions are of more moment than the increase or diminution of a wholesome food supply for mankind.

But, Mr. Chairman, I am not here to discuss any of the phases of the many questions that may be brought to the attention of this Congress. That will be the work of specialists and experts. I am here simply to give you a cordial welcome, and in the name and on behalf of the good people of Florida,

"I will welcome thee and wish thee long."

**Hon. A. Nelson Cheney, of New York, was then presented and made the following response to the governor's address of welcome:**

Your Excellency, Ladies, and Gentlemen: On behalf of the delegates of the National Fishery Congress I desire to thank you, and also the people of Florida, for your most gracious welcome. As you have said, the food problem is a most important one to this country and all countries, and the fish food is not the least important.

Called upon unexpectedly, as I have been, I thought that I could do no better than to state to you the beginning of fish propagation, leading back some centuries. It is said in the encyclopedias that China and Egypt practiced fish-culture. If they did it is not probable that they practiced the fish-culture that we know to-day. The history of our fish-culture has never been written, and I regret that I must trust to my memory as to dates. It is recorded that a French marquis hatched fish in 1420. By those best informed it is believed that he did not do more than to transport the fertilized eggs of fish from one water to another. The real father of fish-culture was Stephen L. Jacobi, a German fish-breeder, who announced the discovery in 1761. He practiced it for some twenty years before that date. His observations were conducted in a little wooden trough, and he himself or his sons continued the work for thirty or forty years. He is undoubtedly the father of fish-culture, as we understand fish-culture to-day. His methods were translated into French, Italian, and English, and George III granted him a life pension.

Down to 1848 there is little or no record of fish-cultural work. Two French fishermen, Remy and Gehin, discovered, as they claimed, the process of hatching fish artificially, and were brought to Paris and there conducted a number of experiments, which happened to be witnessed by Dr. E. S. Sterling, from Cleveland, Ohio, who had as a classmate in Cleveland a Dr. Garlick. Dr. Sterling went abroad to complete his studies, and there witnessed the experiments. In 1853 Dr. Garlick brought trout from Lake Superior to a stream or pond near Cleveland, took the eggs of trout, artificially fertilized them, and hatched them in 1854. Those were the first fish to be hatched artificially in the United States. Dr. Sterling was then in Cleveland and knew nothing about this experiment until he was called on by Dr. Garlick to look at the trout. Dr. Sterling is credited as being the author of the experiments as practiced by Dr. Garlick. Soon after these experiments were made known, as they were in a paper before the Cleveland Academy of Science, it was claimed that the fish had been hatched artificially in 1804 in this country, but this was found to be a mistake.

The first act of any State legislature looking to the propagation of fishes was a resolution passed by the legislature of Massachusetts in 1856. The States formed fish commissions from that date, and in 1872 the United States Fish Commission was organized—largely at the instigation of the American Fisheries Society, as it is now called; it was formerly the American Fish-Cultural Association. One of the first acts of the society was to appoint delegates to go to Washington and recommend the creation of a United States Fish Commission. We all know the workings of the United States Fish Commission and the State fish commissions, because almost every State in the Union has a commission now.

The following telegrams were read:

WASHINGTON, D. C., *January 20.*

The Secretary of State of the United States has the pleasure to extend cordial greetings to the National Fishery Congress now assembled at Tampa, in the hope that its deliberations and results will further the important objects proposed to be attained.

JOHN SHERMAN.

LONDON, ENGLAND, *January 20.*

The world will be benefited by your Fishery Congress. Success to it.

R. MILLER ARNOLD.

DUSSELDORF, GERMANY, *January 19.*

Accept my hearty congratulations for the great movement you have inaugurated. May success attend your deliberations. The International Fishery Congress which you propose to organize is destined to benefit the whole world.

PETER LIEBER.

WASHINGTON, D. C., *January 19, 1898.*

Accept my best wishes for success of National Fishery Congress.

THEODORE ROOSEVELT.

INDIANAPOLIS, IND., *January 19, 1898.*

May the National Fishery Congress be a success is the wish of your Indiana friends.

ALBERT LIEBER.

CHICAGO, ILL., *January 18, 1898.*

Regret exceedingly can not attend Fishery Congress. Sincerely hope meeting will result in greater protection to one of our greatest industries.

H. H. KOHLSAAT.

CHICAGO, ILL., *January 19, 1898.*

Regret extremely inability to attend. Noble industrial enterprise.

THOMAS B. BRYAN.

CHICAGO, ILL., *January 19, 1898.*

Please express to Governor Bloxham and to the Fisheries Congress my regret at being unable to accept his and their very kind invitation, and be good enough to tender my best wishes for the success of the Congress; also present my regards to my old and valued friend, H. B. Plant, whose hospitality I am sure you are all enjoying.

STUYVESANT FISH.

Letters were read from President McKinley, expressing the sincere hope that the Congress would accomplish all that it was assembled for, and from United States Fish Commissioner Brice, conveying his best wishes for the success of the meeting.

In response to calls from the audience Mr. H. B. Plant spoke in part as follows:

I am not a public speaker, and am rarely called upon to make any address, and especially to such an intelligent set of people as I see before me now. It is a pleasure, however, to be here, in the presence of gentlemen who are devoting their time for the benefit of mankind in an effort to promote the propagation and preservation of that excellent food for man—fish. And I thank you, sir, Governor Bloxham, for calling the attention of the American people—not only the American people, but the people of the world generally—to the fact that fish must be protected. It is not an easy matter to protect the fishes of this country, whether it be the fish that swims in the water or the fish that is hidden away in the sands.

You have done well, sir, to call this convention. You have done better, perhaps, than you thought to bring it to the attention of the whole country, as well as to the countries represented here, and to whom invitations have been sent by the Secretary of State of the United States. It is to be regretted that so few foreign delegates have been able to attend. I know, sir, that it was the intention of the Emperor of Japan, through his cabinet, to have sent a delegate here, and I am informed that the occasion for not sending is, as you have announced, a change in the official cabinet of the Emperor. I had the assurance of the prime minister that there was no subject that could be brought to the attention of the Emperor and the cabinet that they felt a greater interest in than that of preserving the fish industry. The Japanese are a great fish-eating people. Fish is their principal article of diet, together with rice, and I am sure that country will regret that it was not able to be represented here.

In response to calls Col. A. A. Wiley, of Montgomery, Ala., made a stirring address.

Mr. W. E. Meehan, of Pennsylvania, from the committee on credentials and permanent organization, announced the list of delegates and made the following report, which was adopted:

We recommend that Mr. A. N. Cheney, of New York, be selected as president of this Congress, and that Dr. H. M. Smith, of Washington, D. C., be selected as secretary of this Congress.

We further recommend that five vice-presidents be hereafter appointed by the president, to preside over the deliberations of this Congress at his invitation.

We further recommend that a committee on resolutions, consisting of one from each State, shall be appointed by the president of this Congress on the nomination of such delegates as may be selected respectively by the representatives from said States.

Mr. Cheney, on taking the chair, made the following address:

Gentlemen of the Congress: I thank you for the honor you have paid me by my selection to preside over your deliberations. I am often asked the question, How many fish arrive at the age that we call adult fish? That is a difficult question to answer; but there is this known: That during a drought in the rivers of Canada, salmon rivers especially, the hatchery men of the State of New York went to the head of one river and secured some salmon eggs. They found that only 2 per cent of the eggs were impregnated. If that, or anything near it, holds true of the salmon family, probably less than 1 per cent is hatched. In all artificial propagation of the salmon family about 95 per cent of all good eggs are hatched. That is a long step forward in fish propagation. We also rear a large percentage of other fish.

But there is still another step, and, as I believe, a most important one, that now deserves attention. Fish-breeders have very little to do with the enacting of laws to protect fish; but it is incumbent upon them to discover some means to feed the fish that are planted in the waters in such large numbers. The State of New York alone last year hatched and planted of various kinds of fish 216,000,000, and the United States Fish Commission, for the year ending June 30, 1897, hatched and planted 586,000,000 fish of various kinds and ages.

Of the value of artificial fish propagation I will only refer you to one item. About 1880 the shad resorts of the Atlantic coast were in a deplorable condition. The shad had fallen off, and something had to be done to restock them, and they were restocked by artificial processes. At that time the catch was 5,162,000 shad. In 1896 the catch was 13,000,000 shad, an increase of 7,900,000 fish, or an increase in the value of the shad product of $1,580,000, on the basis of 20 cents each to the consumer. That will show the benefit derived from artificial fish propagation.

Pursuant to the recommendations of the committee, the chair announced the following as vice-presidents: Hon. Thomas H. Watts, of Alabama; Hon. Eugene G. Blackford, of New York; Hon. George F. Peabody, of Wisconsin; Hon. P. J. Berckmans, of Georgia; Hon. D. P. Corwin, of Pennsylvania.

The Congress then took a recess until 3 p. m.

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The Congress reassembled at 3.30 p. m.

The committee on resolutions, as selected by the respective States, was announced as follows: Alabama, W. K. Pelzer; Florida, John G. Ruge; Georgia, T. B. Felder; Illinois, S. E. Meek; Iowa, A. Holland; Kansas, Albert Finger; Kentucky, Jule Plummer; Louisiana, W. Edgar Taylor; Maine, Henry O. Stanley; Massachusetts, F. Q. Brown; Michigan, Col. Hiram F. Hale; Minnesota, Frank Bruen; Missouri, J. A. Sherman; New Jersey, George L. Smith; New York, Edward Thompson; North Carolina, W. R. Capehart; Pennsylvania, W. E. Meehan; Rhode Island, C. W. Willard; Tennessee, A. J. McIntosh; Vermont, J. W. Titcomb; Wisconsin, Calvert Spensley.

The reading of papers was then taken up, and Mr. W. E. Meehan was called on to present his paper on "The relations between the State fish commissions and the commercial fishermen." The paper was discussed by Messrs. Blackford, of New York; Corwin, of Pennsylvania; Peabody, of Wisconsin; Spensley, of Wisconsin; Cheney, of New York, and Meehan.

The paper of Prof. Jacob Reighard on "Methods of estimating plankton and their value for practical purposes," was read by the secretary.

Prof. W. Edgar Taylor then read his paper on "The establishment of a marine biological station on the Gulf of Mexico."

The paper of Mr. R. M. Munroe, on "The green turtle and the possibilities of its protection and consequent increase on the Florida coast," was read by the secretary.

The Congress then adjourned to meet at 9.30 a. m. January 21.

FRIDAY, *January 21.*

On the assembling of the Congress the chair asked Hon. L. T. Carleton, of Maine, to speak in connection with the discussion of Mr. Meehan's paper of the previous day, especially the matter of the money expended in Maine each season by anglers. Mr. Carleton said:

I did not expect to take any active part in these proceedings. The printed program as distributed does not call for any paper or speech from any of the Maine delegates, and, sir, I am taken very much by surprise to be called upon this morning to make an address upon any subject connected with the deliberations of this Congress. I have been more than content to be a silent listener to the exceedingly interesting papers that have been read and the timely and lively discussions thereon. I count myself indeed fortunate that I was privileged yesterday to listen to the stirring address of welcome of his honor the mayor of this metropolitan city of south Florida, and that I was permitted to sit here as a delegate and hear the wonderfully eloquent speech of his excellency Governor Bloxham, the chief magistrate of this great and powerful and prosperous Commonwealth. To a person coming as I do from the frozen North to this sunny Southland, the voices of these eloquent and distinguished citizens were sweet music to my ears, more charming, I assure you, than "the voices of many waters." And, sir, I feel that I express the sentiments, the feelings, of delegates from the North, from the West, and, in fact, of all the representatives here assembled, when I declare that we are charmed with the cordiality of the people of this State, greatly pleased with your city and State, and are enjoying ourselves to the fullest extent.

Coming as I do to Florida for the second time only—my first visit was in 1861-62—the patriotic words of Governor Bloxham, when, pointing to the Star-Spangled Banner, the emblem of our national unity and liberty, he declared "that for all time we are one and indivisible, and that we have one flag and one country and one destiny," thrilled me through and through. We are indeed, sir, gathered here from every State in the American Union with unity of purpose, unity of interest to do as best we may to advance the great and important fish and game interests of the nation, as citizens of the best country on God's green earth, under the best government ever yet devised by mortal man. Maine sends greeting to the earnest, patriotic, and brave people of the South, and rejoices in your marvelous prosperity, the evidences of which are seen on every hand.

But I am reminded, Mr. President, that I am expected to say something about the fish and game of the old Pine Tree State—the State of Maine. You will pardon me, sir, when I declare to you that Maine in this respect, as in many others, leads the world. In her limitless forests roam countless numbers of the monarch of the forest, the gigantic moose, the bounding caribou, and the graceful, beautiful Virginia deer. In her more than 2,000 inland seas and lakes are found in greater abundance than elsewhere the square-tailed trout and the landlocked salmon. The great dailies and sporting papers of the American continent are in the habit of referring to Maine as the "Paradise of the sportsman," and this is a very appropriate title, as nowhere else is there such sport to be had for either rod or rifle. We have an area of about 30,000 square miles in extent, and from the nature of the soil and climate, affording food and cover for numberless herds of deer, caribou, and moose, not to speak of the countless flocks of birds, both resident and migratory, including the ruffed grouse, woodcock, snipe, wild geese, black duck and wood duck, and an endless variety of sea birds—and the whole world is fast learning of our advantages in this respect. In her majestic rivers, those great highways from the mountains to the sea, is found in increasing numbers the best fish that swims the ocean blue, the Atlantic salmon. Wise, well-considered laws we have and an enlightened public sentiment.

Ten thousand citizens of other States during the open season last year, now just closed, came to Maine to fish and hunt, employed our 1,300 registered guides, skilled guides, and spent $4,000,000 among our people and killed 10,000 deer, 250 moose, 230 caribou, and 160 bears, while $6,000,000 more were spent there by non-residents last year, by visitors to our seashore and inland summer resorts, making $10,000,000 expended in Maine last year by non-residents for pleasure.

Do you wonder that the people of Maine are marvelously interested in fish and fisheries? We follow the example of the great Apostle Peter, we go a fishing, and invite everybody to come and do likewise. We have a health-giving, invigorating climate, wondrously charming and enchanting scenery. There is not a poisonous reptile, nor ravenous beast, nor poisonous insect in all her borders; and in her mountain streams, numerous as the sands of the seashore, are the protected nurseries of our lakes, wherein are millions of speckled beauties, the brook trout, and these feeders are so numerous,

so well protected and restocked by artificial propagation as to give assurance that fishing in Maine will be better and still better as the years go and come.

Something has been said here about the constitutional right of a State to enact restrictive or protective laws regulating the times in which and the circumstances under which inland fish and game may be taken. That question has fortunately been settled for all time in the United States. The United States Supreme Court in a late decision has declared that the people of a State, in their sovereign capacity, own the fish and the game within its borders, and may say through its legislature how, when, and where the game and the fish may be taken and disposed of; in other words, the legislature may give a qualified property right or ownership to fish and game lawfully taken. We have found by experience that protective laws are necessary, and that these laws must be enforced. Why, do you know that down in Maine if a person is shot by another while hunting it is called an accident, but if a person shoots a moose or a caribou unlawfully we imprison him four months "without the benefit of clergy."

As true disciples of Isaak Walton we propagate artificially the trout and the salmon, and, aided greatly by the United States Fish Commission, we are constantly making the fishing better, and the multitude is constantly growing larger who come among us, and let me say, though I am no prophet, or the son of a prophet, but only a down-east Yankee, that in these times of wages growing less and still less, and the army of the unemployed constantly being augmented, the Congress of the United States can display wise statesmanship by giving earnest attention to the improvement of fishing, better fishing to those who go down to the sea in ships, better opportunity to secure this good, wholesome food, greater opportunity to willing hands to engage in this great industry. Dollar wheat may be a blessing to the farmers of the West, but it means dearer bread to the toiling millions, but better than dollar wheat would be a greater abundance of fish and game and enlarged opportunities to our laboring people to engage in this great, important, and growing industry.

The committee on resolutions reported organization by the election of Hon. H. O. Stanley, of Maine, as chairman, Hon. Edward Thompson, of New York, as vice-chairman, and Mr. W. E. Meehan, of Pennsylvania, as secretary. The committee also presented a resolution calling for a statement at each session of the program for the next session, which was adopted.

The secretary gave notice of a complimentary excursion to the Manatee River provided for the delegates by the Tampa Board of Trade on Saturday, January 22, on the steamer *Margaret;* also a trip on the U. S. Fish Commission steamer ***Fish Hawk*** on Tampa Bay, for exhibiting the methods of deep-sea dredging, etc.

The following telegram was read:

OMAHA, NEBR., *January 20, 1898.*

Unable to be present at meeting of Congress, but send greeting and invite all members to visit Trans-Mississippi and International Exposition at Omaha during meeting of American Fisheries Society third Wednesday in July, current year.

W. L. MAY,
*President American Fisheries Society.*

The following letter from Mr. A. Milton Musser, of Salt Lake City, Utah, was read by the secretary and discussed by Mr. Edward Thompson, of New York:

It would give me great pleasure to attend the Fishery Congress, were it possible for me to do so.

For the information of the managers I will give brief data respecting the Utah fish industry. The native fishes consist of mountain trout, Williamson's whitefish (both very choice), suckers, chubs, and mullets; more suckers than all others put together.

During my labors for the Territory and the State as fish and game commissioner, I introduced from the East and West and planted in our public waters some 11,000,000 of choice fishes. Most of these were gifts from the general government, and consisted of whitefish, shad, black bass, rock bass, perch, crappie, sunfish, speckled, rainbow, and lake trout, catfish, eels, carp, etc. We hope soon to have an abundant supply of the best of these fishes for home consumption and sale to our neighbors. We have not yet attempted to increase our supplies by artificial means. Our legislators thus far have refused to appropriate funds for a public hatchery. Long ago I came to the conclusion that the only way to

keep our mountain streams stocked with trout would be by turning into them a few million fry every year from a local hatchery. The basses, etc., need no artificial manipulation. They multiply very rapidly, and, as a rule, find suitable places to spawn in the waters in which they are planted.

The salinity of Great Salt Lake is too great for the propagation of fishes. Nothing larger than the brine shrimp is found in its waters. At different periods since the year 1850 the following densities have been observed by different persons: 22.28, 14.99, 16.716, 19.557, and 22.

As has been suggested, I hope your Congress will find some process for drying fish when taken from the water, so that they can be shipped as hay, cotton, etc., are shipped to the marts. This would indeed be a grand consummation, especially if it is comparatively inexpensive.

I have all along contended that an acre of water can be made more remunerative than an acre of land, and when the comparative labor and expense bestowed upon their respective cultivation is considered, the force of the conclusion is irresistible. Our large lakes have never been thoroughly prospected. Only a very limited area has been seined, and we do not know what might be found in the great areas not yet seined.

Under the pressure brought to bear on our legislators by selfish men, an abnormal and no doubt unconstitutional provision was put in the fish and game law of the State, which obliges seiners to hire and pay the warden for his presence during the seining. The provision reads:

"Provided, that before any person shall use a seine * * * such person shall secure the presence of either the county warden or his deputy, who shall be paid not to exceed $2 per day by the party drawing the seine."

I would be surprised to find any such provision in the fish law of any other State in the Union. To discriminate against fishermen alone is class legislation, and to oblige them to pay a second party to keep them from breaking the law is, indeed, to say the very least, remarkable legislation. The result is that nearly all the seiners are forced out of the business. Another source of evil, which nearly amounts to a crime, is that carp, suckers, etc., are permitted to multiply prodigiously and prey upon the spawn and fry of the good fish and to occupy the waters largely to their exclusion. Further, the poor people who can not afford to pay from 15 to 30 cents per pound for bass, trout, etc., are barred from purchasing the commoner kinds, which by this lawless law virtually prevents their being caught.

The president, having called Vice-president Corwin to the chair, presented his paper, "The Hudson as a salmon stream." In the discussion which followed Messrs. Meehan, Corwin, Titcomb, Thompson, Spensley, Peabody, and Cheney participated.

Dr. H. C. Bumpus, of the Rhode Island Fish Commission, then read his paper on "The importance of extended scientific investigation." In discussing the paper Hon. E. G. Blackford, of New York, said:

The point emphasized by Professor Bumpus as to the proper handling of fish is a very important one, especially to the fishermen of Florida. Some ten years ago, when the first shipment of fresh fish was made to New York from the State of Florida, they were thrown into large casks, indiscriminately, and chunks of ice weighing 15 pounds each were put upon top of the fish, then another layer of fish was thrown upon the ice, and again another layer of broken ice, and the whole put under a canvas cover on the steamer. These were Spanish mackerel. On the arrival of the steamer at New York the entire shipment had to be thrown away, as a large portion of the fish were spoiled by decomposition, and the remainder were so badly bruised as to be unfit for market purposes. This was a costly experiment for the shipper; yet year by year experience has demonstrated to the shippers of fish the importance of careful handling and packing, so that now mackerel, pompano, sheepshead, and other fish are sent from the most remote parts of Florida to the New York market in perfect condition, and bring a fair and remunerative price to the producer.

As an example of the increased returns to the shippers from careful handling, I call the attention of the convention to the fact that certain shipments of shad, going to the New York market from North Carolina, bring from 25 per cent to 40 per cent more than other shad from the same locality. For instance, a certain shipper from Albemarle Sound, North Carolina, pursues the following method: His shad are carefully taken from the nets and placed in a cold room until thoroughly chilled, then packed in boxes; first a layer of fine ice, broken into lumps no larger than chestnuts, is placed in the bottom of the box; then the shad are placed in rows, lying on their backs, making a complete layer on the ice; then a layer of fine ice is spread over the bellies of the shad, and on this layer is another

row of shad; all the shad are packed in a similar way; then the top of the box is filled with fine ice and the cover nailed securely on. These shad reach the New York market in a perfect condition, and so well known has this shipper's mark or brand become that the buyers are always on the lookout for this particular brand, and these shad are the first that are sold and bring the highest prices. On arriving in New York the fish have not moved from their position in the box, the ice is still intact, and on opening the box we find all the fish to be in a perfect condition, each scale undisturbed, and the whole presenting the appearance of a glistening jewel just taken from a casket.

As I said before, these fish bring a very much greater price than other fish shipped from the same locality; the latter have been packed in a careless and slovenly way, and the packages when opened in the New York market do not look inviting, and, as a result, are not sought for and can only be sold by marking down the price.

What I wish to impress upon the shippers and fishermen is that for every dollar invested in labor and ice in packing the fish they will receive $10 in return.

Mr. J. M. Willson, jr., of Kissimmee, Fla., read a paper on "Florida fur-farming," relating to the breeding of otters in captivity, which was briefly discussed by Mr. Blackford.

A pair of live otters raised in captivity were exhibited.

Col. F. C. Zacharie, of Louisiana, brought up the subject of crayfishes in the Mississippi levees, showing the damage done by a certain species, which appeared only during high water. Dr. H. C. Bumpus, Dr. H. F. Moore, and Mr. C. H. Townsend made remarks on the subject.

A recess was then taken until 3 p. m.

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On the reassembling of the Congress, the president called Vice-president Peabody to the chair.

The afternoon session was occupied in the reading of papers and discussions thereon.

Prof. H. A. Smeltz, of Tarpon Springs, Fla., delivered a paper on the "Florida oyster-bars, their depletion and restoration," and exhibited specimens of live oysters attached to various objects, from the vicinity of Tarpon Springs. Mr. Blackford, Dr. Moore, and Colonel Zacharie spoke on the subject.

In the discussion of the paper Mr. Blackford said:

One point as to the oyster question brought forward so very interestingly by Professor Smeltz, in speaking of the efforts that should be made to obtain legislation: He seems to lay a great deal of force upon the fact that a revenue might be obtained from the leasing or selling of these grounds for oyster-culture. I think that is the wrong end of it. I think that the terms should be such as to invite oyster-culture, to protect the industry by giving the man the right, by lease or selling the ground outright, on such terms as would encourage him to go into the business. There is no reason why a revenue should be sought from the oyster-cultivator for the purpose of lowering the tax upon the farmer who occupies the upland. I think this the wrong way to go at it. I think we should make legislation so as to encourage and promote oyster-farming, to obtain such an immense product that it would bring a large business to the State, and consequently wealth, but not particularly for the purpose of raising a revenue for the State and thereby reducing the taxes of other people.

Dr. Moore said:

I have given the subject of oyster-culture some attention during the last year or more. I have been interested in it more or less for a number of years, and I have given particular attention to the facts which Mr. Blackford has just brought up. I am inclined to agree with what he has said. I think the main unfortunate feature of our oyster legislation heretofore has been the effort to get

large income. The prospects of acquiring a large revenue to the State have been held out. The income to be derived from oyster-culture has been very much magnified by those who have given the subject attention, and legislatures have become imbued with an entirely erroneous idea concerning the matter. Their aim has, therefore, been to secure as large an amount of the revenue as possible, and in many cases this has resulted in the enactment of laws which were practically prohibitory, so far as oyster-culture is concerned. This is the case in the State of Virginia. They have there an enactment allowing the leasing of the land. The annual rental was at first 25 cents per acre. The legislators from the interior of the State of Virginia believed that vast revenues were being derived from these oyster-bars, and it immediately became their aim to secure a larger share of this revenue for the State. The consequence has been that the annual rental has been raised, to the detriment of oyster-culture.

Col. F. C. Zacharie, in discussing the subject, spoke as follows:

As a member of the bar, as a lawyer, I desire to say something in regard to the laws which we have in the State of Louisiana, supplementary to the comments of Mr. Blackford and Dr. Moore. I am not familiar enough with the oyster laws of the other States to say what their provisions are, or what is the principle upon which the oyster tax is based. One of the chief difficulties which we have had in Louisiana has been that oyster-culture is looked upon by a large portion of our legislators as an experiment, and people from the interior are very ill-disposed toward making any experiments which increase taxation upon them. The theory of taxation is that it is a correlative and corresponding duty between the citizens and the government; that the government shall give him protection in life, liberty, and property, and that the tax which is levied on him is simply a correlative duty from the taxpayer to pay his proportionate share toward that protection.

Now, in view of this, we have sought in Louisiana not to derive any revenue for the State beyond the needs of the regulation and protection of the oyster fishery, and so we have held out for very small taxation or fishing licenses, and have a tax upon planted oysters—a very small tax, for the purpose of meeting the expenses of the particular production and regulation of that particular industry—so that we have not sought to make the oyster industries of the State a source of general revenue. This is a tentative process or principle, because we look forward to the day, or at least some of us do, when these industries will become very much developed and very valuable, and of course as they become more valuable and remunerative and the protective system is more detailed and complicated, then will be the time for the State to tax that property, as it does all other property, in proportion to its value.

I believe I make myself clear in announcing that the policy of my State has been not to derive a revenue from the oyster industry as a matter of general revenue, but merely to attempt to raise a revenue sufficient to regulate and protect the industry, and when we placed it on that basis we found that the people from north Louisiana and the interior middle district of Louisiana were perfectly willing to pass any legislation which they thought productive of good in regard to the oyster industry, providing it did not cost them anything.

Mr. Meehan read the paper by Dr. Bushrod W. James, of Philadelphia, on "International protection for the denizens of the seas and waterways."

Mr. J. F. Welborne, of Sanford, Fla., read a paper by Mr. George W. Scobie, of Titusville, Fla., entitled "The fishing industry on the east coast."

Dr. H. F. Moore read an article by Dr. J. P. Moore, of Philadelphia, on "The utility and methods of mackerel propagation."

Adjournment was then taken until Monday morning, January 24.

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SATURDAY, *January 22.*

In the evening, in the music hall of the Tampa Bay Hotel, Mr. Charles H. Townsend, of the United States Fish Commission, gave a lecture on "The world's seal fisheries, with special reference to the American fur-seal." The lecture was illustrated by lantern slides.

MONDAY, *January 24.*

The meeting was called to order by President Cheney. He presented a letter he had received from Mr. Stevison, of New York, relative to a close season for tarpon in Florida, and asked any persons who were informed on the subject of the spawning time of the tarpon to report at the afternoon session.

The president introduced Mr. Chow Tsz-chi, who made the following response in behalf of the Chinese Government:

Mr. President and Gentlemen of the National Fishery Congress: I thank you for your kind reference to my Government and also for honoring the Government of China with an invitation to be represented at this important gathering of learned and distinguished gentlemen who have assembled here in the interest of a work which is destined to benefit mankind and all the nations of the earth. How I long for words in your language to express the feelings of my heart for the many kind attentions extended to me! I came to you a stranger; I leave you as a brother. Governor Bloxham in eloquent words referred to the early pioneers of Florida; I would write in words of gold the deeds of Henry B. Plant, the modern Christopher Columbus, who rediscovered Florida and built the palace which now shelters us. I will ever remember you, kind friends; my heart goes out to you in thanks unspeakable.

May peace, prosperity, and happiness be with you and the people of the United States forever!

The president presented Capt. E. N. del Arbol, of the Spanish navy, who said:

I wish to congratulate you on the interest you are taking in such an important matter to you and to the world at large as that which pertains to fish and fisheries; to congratulate you, too, on the numerous and valuable papers that are being read here; to thank you in behalf of my country for the courtesy in inviting it to participate in this Congress, and for the kindness you have shown to its delegate; and allow me to express my desire that in some time to come all the navies of the world, to one of which I belong, may be a large police force whose principal duty may be to protect fish and fisheries for the benefit of mankind and to enforce the wise laws enacted for this purpose.

The committee on resolutions reported the following, which were adopted:

Whereas it is the opinion of this Congress that every State should have a well-organized and active board of fish commissioners, whose duty it should be to foster the fishery interests of their respective States; to advise the legislatures in all matters pertaining to fishery legislation; and to secure by protective, fish-cultural, and educational methods the preservation and increase of useful water products: Therefore, be it

*Resolved,* That this Congress recommends to those States having no fish commission the appointment of such at the earliest practical date.

*Resolved,* That at least one member of each commission should be a man of scientific attainments, competent to intelligently deal with the biological phases of fish commission work.

*Resolved,* That a copy of these resolutions be sent to the governor of each State having no fish commission, requesting him to bring the matter to the attention of the legislature; and that a copy also be sent to the governors of those States which now have such commissions.

The following resolutions were also reported and adopted:

Whereas, recognizing the great extent of the Gulf coast line and the fact that this section possesses excellent food fishes in greater abundance than elsewhere; that her superior oyster facilities are being rapidly depleted by lack of proper protection and investigation; that this section possesses shrimp and other resources of great interest, with the possibility of development of still other industries as yet untried; that climatic conditions being different from other sections of our country renders it necessary that the fauna of this region be given individual study; and, furthermore, wishing in every reasonable way to stimulate and encourage each and all of the States of the Gulf region to a more active interest in our fisheries: Therefore, be it

*Resolved,* That this Congress express itself as favoring the location and equipment of a national fish-hatchery and laboratory at some central and suitable location on the Gulf coast, to be under the control and direction of the United States Commission of Fish and Fisheries.

*Resolved,* That this Congress appoint a committee of five, one from each of the States bordering the Gulf, whose duty it shall be to urge upon the United States Congress the necessity for making an appropriation for carrying on this hatchery and laboratory.

The committee appointed in pursuance of this resolution was later announced, as follows: Florida, Mr. John G. Ruge; Alabama, Maj. A. A. Wiley; Mississippi, Mr. Frank Howard; Louisiana, Prof. H. A. Morgan; Texas, Prof. W. W. Norman.

In acknowledgment of the telegram from Mr. W. L. May, president of the American Fisheries Society, the following resolution was adopted:

*Resolved*, That the National Fishery Congress now assembled in Tampa, Fla., accepts the greeting and invitation of the American Fisheries Society, and hereby expresses the hope that the purpose and result of this Congress may, with their aid and approval, become an international one in full effect.

*Resolved, further*, That the secretary of this Congress transmit a copy of this resolution to the President of the American Fisheries Society.

A resolution was also adopted providing that in the presentation of papers preference be given to those accompanied by their authors, and another recommending that the proceedings of the Congress be terminated on this date.

Dr. H. F. Moore, in referring to the resolution relative to the establishment of a biological station on the Gulf coast, called attention to the large prawns found in the waters of Tampa Bay by the *Fish Hawk* while engaged in experimental trawling, and their prospective importance to the State.

Col. F. C. Zacharie discussed the resolution relative to fish commission boards, and asked for information relative to the organization of such boards. He gave notice of the calling of a proposed meeting of the people of Louisiana interested in fishery matters, and announced that later there would be a convention of the Gulf States for the purpose of securing uniform legislation and interstate cooperation.

Mr. Meehan referred to the valuable aid rendered the Pennsylvania Fish Commission by fish-protective associations, and the financial assistance given the commission after the failure of the legislature to make any appropriation for the current year.

The president then yielded the chair to Hon. E. G. Blackford, vice-president, who spoke briefly on the oyster question, and presented Dr. H. F. Moore, who delivered a paper on "Some factors in the oyster problem."

Mr. Edward Thompson, shellfish commissioner of New York, spoke on the extent of the oyster-planting business. His remarks, in substance, were as follows:

The sensible oysterman leaves natural grounds alone. After Mr. Blackford had secured a law to permit the use of barren bottoms in New York, the business increased rapidly. The great importance of liberal laws, the prohibition of poaching, and the taking up of barren grounds should be emphasized. The business is almost certain to be successful. The fifteen-year lease is a failure, as five years may be required to get a set. There should be a perpetual lease. I am a successful grower, and give the credit of it to Mr. Blackford, the gentleman in the chair. The present law ought to give place to the old Blackford law, which is good enough for all. All the members should go home and secure the enactment of liberal planting laws, where none exist. I once got a lease of 200 acres of bottom in Long Island Sound, spending $9,000 in cleaning the grounds, and planted 45,000 bushels of shells and 1,500 bushels of large oysters thereon. In a year I sold out my half interest for $30,000 and bought it back in two years for $50,500 at public auction.

Mr. John G. Ruge, of Apalachicola, Fla., then read a paper on "The oysters and oyster-grounds of Florida."

In response to an inquiry of Mr. Blackford as to whether any delegate could present information on the subject of raising seed oysters in claires or ponds according to the French system, Colonel Zacharie spoke as follows:

I know of no such experiment having been tried in the Gulf States or indeed anywhere in this country. I may add, however, that members of the Bayou Cook Fish and Oyster Company have discussed the feasibility of an experiment in that direction on a small scale on their property, as it

could be tried at trifling expense. The current in Bayou Cook, like that in nearly all the salt or brackish bayous, while bringing down the finest food for the fattening of planted oysters, prevents to a great degree the satisfactory "fixing of spat," as the spawn is carried out, in large part, into Bastian Bay or the Gulf, into which Bayou Cook empties, where it is nearly entirely lost. The reckless and wasteful fishing of the natural reefs in that neighborhood has denuded and destroyed them, so that planters in the bayou now have to go over 60 miles to the westward, mainly to Timbalier Bay, to get seed or young oysters for planting. The Timbalier natural reefs are being rapidly exhausted from the same causes as the eastward, and fishing in a few years will be entirely exhausted unless the matter is regulated by stringent legislation and execution of the laws. The planters, and indeed the fishers for market, will be forced to go farther west still when the Timbalier fisheries are destroyed.

It is therefore contemplated for the company to raise its own seed in the following manner: The soil on the banks of the bayou being soft and marshy, an area of a quarter or half an acre can be readily excavated by spading to the depth of from 4 to 6 feet. An inlet, say 10 feet wide, can be cut in from the bayou so as to admit the waters thereof, and a similar outlet can be made into the bay, through which the water can be partially discharged into the sea at low tide, the reverse flow taking place at high tide. These openings may be closed by close-meshed nettings of galvanized wire or other suitable material, so as to protect the breeding oysters and spawn in the pond to a great extent at least from drumfish, starfish, boxers, conchs, crabs, and other enemies of the oyster. Benches of poles can then be erected in the "claire" or pond, and on them will be placed earthenware tiles, or half tiles, previously limed. These tiles or half tiles can be procured from a tile factory a few miles above on the Mississippi River at a nominal price for the broken or damaged unsalable half tiles which would answer the purpose.

The pond or "claire" can then be stocked with breeding oysters, carefully selected from prime stock. Indeed, by importation from northern and eastern quarters, crosses could be experimented with by interbreeding with the native bivalve. In the spawning season the ova of the female and the milt of the male would, in this comparatively still water, more readily coalesce with their "affinities" of the opposite sex, and a larger product of the embryo oyster be furnished. This embryo or "spat" would readily "fix" on the tiles. When this spat is sufficiently developed in size to plant, the wire-netting screens can be removed and small flatboats or shallops introduced into the "claires," the tiles covered with spat removed from the benches and loaded on the flatboats. These being carried out into the bayou, the young plants can be scaled off the tiles with trowels or similar instruments, and dropped into and on the plant or growing beds, there to fatten, grow, and mature until ready for market. The tiles being then relimed may be placed back in the "claires" ready for the "fixing" of the next season's spat. In other words, the "claires" would be used as nurseries for the raising and growing of spat, which might be perhaps further improved and developed by artificial feeding.

The system is called the "French," but is in fact the old Roman method, as frequent mention is made in the old Latin writers of "oyster ponds." The French, it is said by French writers, have also made use of these "claires" as "écoles des huitres," by which they profess to be able to teach the oysters, by gradually increasing the length of time during which the oyster is without water, to take in an extra supply of water like a camel about to cross a desert, so as to last through transportation on long voyages and keep the mollusks in good condition. It is not definitely known that this last method has ever been tried in America, although it is believed that it has been—and that successfully. American biologists (humorously styled here "oyster sharps") are, however, skeptical on the subject. The French governmental reports seem to substantiate the practicability of the method.

In case the idea is adopted, when the Bayou Cook Company gets into operation it will report progress and results to the United States Fish Commission. If successful, each oyster-culturist will be independent of the natural reefs, can obtain all the necessary seed or spat in his own inclosure, and vastly improve the poorer species of the native oyster by interbreeding with other and choicer varieties, besides improving much the preservation of oysters in shipment in their full excellence when delivered to the consumer at far distant points. If successful, it could be conducted on a very large scale, and it would be profitable for some planters to embark in the business of raising and selling the young plants exclusively as a special branch of the trade. It would produce a revolution in oyster-culture.

In reference to the opposition of oystermen to the enactment of oyster-planting laws, Mr. Blackford referred to meetings at which the oyster fishermen had had their

opposition allayed by being shown that they would have more regular and remunerative employment on planted grounds than if they worked on the natural grounds.

Mr. John Y. Detwiler, of New Smyrna, Fla., read a paper on "Experimental oyster-culture."

A recess was then taken until 3 p. m.

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At the opening of the afternoon session a paper entitled "The Florida commercial sponges: their nature, protection, and cultivation," was read by Dr. Hugh M. Smith and discussed by Professor Smeltz and the author.

The committee on resolutions reported the following, which were adopted by a rising vote:

*Resolved*, That the National Fishery Congress acknowledges the call of his excellency W. D. Bloxham for the existence of this Congress, as well as the inception of the idea to Col. T. T. Wright, and hereby gives an expression of appreciation and grateful thanks to Mr. H. B. Plant, not only for his general interest in the purpose of this Congress, but for his liberal hospitality in furnishing the use of the hall for the Congress, the excursion by train and steamer; and in thus manifesting our appreciation we also gratefully acknowledge the courtesy of his honor M. E. Gillett, mayor of Tampa, as also of Mr. H. Cunningham, the efficient secretary of the Board of Trade of Tampa, for their cordial greeting; be it further

*Resolved*, That we extend our thanks to Lieut. Franklin Swift for the pleasant trip on the United States Fish Commission steamer *Fish Hawk*; be it still further

*Resolved*, That the secretary of the Congress furnish a copy of these resolutions to those above mentioned.

The question of publishing the proceedings of the Congress being under consideration, the following resolution was passed, and pursuant thereto Dr. H. M. Smith and Mr. W. E. Meehan were selected by the chair to constitute, with himself, the committee on publication:

*Resolved*, That the president of this Congress appoint two persons, who, with himself, shall constitute a committee on publication, with powers to arrange for the editing, printing, and distribution of the papers here presented.

Col. F. C. Zacharie, of New Orleans, presented his paper on "The oyster industry of Louisiana," which was discussed by Mr. Blackford and Colonel Zacharie.

Dr. S. E. Meek, of Chicago, read a paper entitled "The utility of a biological station on the Florida coast in its relation to the commercial fisheries."

Dr. H. C. Bumpus brought up a topic which had been referred to in the paper of Professor Smeltz read on January 21, namely, the alternating sexuality of the oyster. He asked the author to state the basis for his remark that the sex of the common Eastern oyster changes from season to season, and requested an outline of the experiments on which the statement was founded. Professor Smeltz said he had had about 400 oysters under observation, and about 2 per cent of them apparently exhibited the condition stated. Dr. Bumpus, Dr. Moore, and Mr. Blackford referred to the great liability of error in the experiments and observations, and thought Professor Smeltz should not make a positive statement until crucial tests had been applied.

Owing to the fixing of an earlier date for final adjournment than had been anticipated, a number of papers could not be read. These were read by title by the secretary, who outlined their scope.

# INTERNATIONAL FISHERY ASSOCIATION.

On January 25, 1898, at the close of a session of the National Fishery Congress, convened at Tampa, Fla., persons interested in the formation of an international fishery association met. Prof. Herman C. Bumpus, of Brown University, Providence, R. I., a member of the Rhode Island Fish Commission, was made temporary chairman, and Dr. Hugh M. Smith, of the United States Commission of Fish and Fisheries, was made temporary secretary. The following letters were read:

[Society for Professional and Technical Instruction in the Marine Fisheries.]

25 QUAI SAINT-MICHEL,
*Paris, November 19, 1897.*

Dr. H. M. SMITH,
*United States Fish Commission:*

We will hold at Dieppe, in the latter part of August, 1898, an International Congress of Marine Fisheries under the presidency of M. Perrier, member of the Institute. We will organize in 1900 a third International Congress. If you organize at the Congress of Tampa an International Fish Society, this society would have charge of the organization of the Congress of Dieppe and of that of Paris in 1900.

I hope that you have requested the minister of marine to be represented at the Congress of Tampa. If not, it would be necessary to do so immediately, in order that we may avail ourselves of the opportunity.

Please accept, dear doctor, the assurance of my highest consideration.

E. CACHEUX,
*President of the Society for Professional and Technical Instruction in the Marine Fisheries.*

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PARIS, *January 14, 1898.*

Mr. PRESIDENT: Not being able, to my regret, to be present with you at this time, I desire to announce to the members of the Congress at Tampa, that the Second International Congress of Fisheries and Agriculture will assemble at Dieppe on September 5, 1898. At the general meeting the following questions will be considered:

1. The economical transportation of fish by railroads.
2. Modifications of the rules relating to lights on fishing vessels, to avoid collisions.
3. Actual conditions of oyster-culture in France, and of the culture of mollusks.
4. Mutual agreements among sea fishermen to provide remedies in case of loss of apparatus, etc.
5. Effects of trawling near the coast.

At the meetings of the sections various questions of interest will be discussed, among which I will cite:

Diseases caused by the consumption of fish and shellfish taken from polluted waters.

Practical means of improving the lodgings of marine fishermen.

Charts of fishing banks.

I have addressed to you by the same mail a report of the proceedings of the first congress.

It will be desirable that the United States unite with us in organizing the International Society of Marine Fisheries or, rather, a permanent committee which will interest itself in such international congresses, and especially that which will be held in Paris in 1900.

Please accept the assurances of my highest esteem.

E. CACHEUX,
*President of the Society for Professional and Technical Instruction in the Marine Fisheries.*

A telegram was read from Hon. John Sherman, Secretary of State of the United States, expressing his interest in the formation of an international association and stating that he would take pleasure in bringing the matter appropriately to the attention of foreign Governments.

After informal discussion of the importance and functions of such an association, the following resolutions were adopted:

*Resolved*, That pursuant to published announcements, there be organized at this congress an *International Fishery Association* for the promotion of friendly relations, the exchange of information and experience in fishery and fish-culture matters, and cooperation in preserving and protecting the fishery resources among the nations of the earth.

*Resolved*, That there be chosen at this time by this meeting a president, two vice-presidents, and a secretary and treasurer, and a committee, not to exceed forty persons, who, with the officers named, shall constitute an executive board. This board is authorized to appoint an advisory board, consisting of persons of all nations who are prominently identified with the fisheries, fish-culture, fish protection, and the study of water animals. The executive board is also empowered to select a suitable number of vice-presidents at large for the United States and foreign countries and any other officers who may appear desirable. This board is further authorized to formulate rules for the government of the association, to fill vacancies, and to call meetings, five members constituting a quorum.

The following officers were then elected:

*President:* Prof. Alexander Agassiz, Museum of Comparative Zoology, Cambridge, Mass.

*Vice-Presidents at Large:*

Prof. Edmond Perrier, Paris, France, member of the Institute and president of International Congress of Fisheries and Agriculture to meet at Dieppe, France, in September, 1898.

Hon. A. Nelson Cheney, chief fish-culturist of the State of New York, Glens Falls, N. Y.

*Secretary-Treasurer:* Dr. Hugh M. Smith, U. S. Commission of Fish and Fisheries, Washington, D. C.

The following members of the executive board were also elected:

Hon. George M. Bowers, United States Commissioner of Fish and Fisheries (ex officio), Washington, D. C.
Hon. A. A. Adee, Assistant Secretary of State, Washington, D. C.
Hon. L. T. Carleton, chairman Maine Fish and Game Commission, Augusta, Me.
Mr. Clarence B. Mitchell, Boston, Mass.
Prof. Herman C. Bumpus, member of Rhode Island Fish Commission, and professor of comparative anatomy in Brown University, Providence, R. I.
Hon. Eugene G. Blackford, New York, N. Y.
Mr. William E. Meehan, Pennsylvania Fish Protective Association, Philadelphia, Pa.
Prof. Theodore Gill, Smithsonian Institution, Washington, D. C.
Dr. W. R. Capehart, Avoca, N. C.
Hon. W. D. Bloxham, governor of Florida, Tallahassee, Fla.
Col. F. C. Zacharie, New Orleans, La.
Prof. Jacob Reighard, professor of zoology, University of Michigan, Ann Arbor, Mich.
Prof. S. A. Forbes, professor of zoology, University of Illinois, and director of the Illinois Laboratory of Natural History, Urbana, Ill.
Prof. David S. Jordan, president Leland Stanford Junior University, California.
Mr. Marshall J. Kinney, Astoria, Oreg.
Prof. C. C. Prince, Superintendent of Fisheries of Canada, Ottawa, Canada.
Mr. Adolphe Neilsen, Superintendent of Fisheries, St. Johns, Newfoundland.
Mr. R. B. Marston, The Field, London, England.
Mons. Raveret-Wattel, Paris, France.
Mr. S. Jaffé, Osnabrück, Germany.
Mr. C. J. Bottemanne, Berg-op-Zoom, Netherlands.
Dr. C. G. Joh. Petersen, Copenhagen, Denmark.
Dr. Rudolph Lundberg, Stockholm, Sweden.
Prof. A. Landmark, Inspector of Fresh-water Fisheries, Christiana, Norway.
Mr. Alexander Hintze, Helsingfors, Finland.
Dr. Nicolas Borodine, Russian Association of Fisheries and Fish-Culture, Uralsk, Russia.
Dr. Anton Dohrn, director of the Naples Laboratory, Naples, Italy.
Capt. Guilio Ricotti, Leghorn, Italy.
Capt. E. R. del Arbol, Spanish Navy.
Mr. Chow Tsz-chi, Chinese Legation, Washington, D. C.
Mr. K. Ito, Hakodate, Japan.

The letters of Mr. Cacheux and the telegram of Secretary Sherman were referred to the executive board, after which the meeting then adjourned, subject to the call of the board.

HUGH M. SMITH, *Secretary.*

# METHODS OF PLANKTON INVESTIGATION IN THEIR RELATION TO PRACTICAL PROBLEMS.

By JACOB REIGHARD,
*Professor of Zoölogy, University of Michigan.*

In this country the fisherman as a rule continues to fish in any locality until fishing in that locality has become unprofitable. He then moves his operations to new waters until these in turn are exhausted. He is apt to look upon each new body of water as inexhaustible, and rarely has occasion to ask himself whether it is possible to determine in advance the amount of fish that he may annually take from the water without soon depleting it.

On the other hand, the fish-culturist is apt to plant his fry in waters that are quite unsuited to them or to plant them in numbers far in excess of what the water can support.

The fisherman proceeds as a farmer might who imagined that he could continually reap without either sowing or fertilizing; while the fish-culturist proceeds often as if convinced that seed might grow on barren soil or that two seeds might be made to grow in place of one.

In some regions the public is beginning, through the machinery of the State, to insist that its interest in the fisheries be guarded; that neither fishing nor planting of fish should be carried on in excess; and the time is fast approaching when the State will everywhere exert its authority to control the fisheries. It will then become necessary to determine, at least approximately, the productive capacity of any body of water.

It is the purpose of the present paper to discuss the method by which it has been proposed to determine the relative productive capacities of bodies of water. This method, for there is really but one, was first proposed by Hensen[1] in the sea, and is based upon two principles. It is known that the many species of plants and animals which inhabit a body of water are interdependent. In the final analysis all the fishes are dependent, directly or indirectly, on the minute floating plants and animals which, taken together, we call the plankton. The total mass of plankton is, in most bodies of water, so great that, in comparison with it, it is customary to neglect the fixed plants along the shore and the animals that they harbor. That the plankton lies at the base of all life in the water is, then, the first principle.

The second principle is that the plankton, considered as a whole, is uniformly distributed. There is no longer any doubt that some constituents of the plankton, e. g., the crustacea, may not be distributed uniformly.[2] Wherever measurements have been

[1] Hensen, Victor. Ueber die Bestimmung des Planktons. Kiel, 1887.
[2] Marsh. On the Limnetic Crustacea of Green Lake. Transactions Wisconsin Academy of Science, Arts, and Letters, vol. 11, 1897, pp. 179–224.

made of the total plankton it has, on the other hand, been found[1 2 3] that this is so distributed that nearly the same volume of it occurs under each square yard of the surface at equal depths.

From these two principles Hensen concluded that a determination of the amount of plankton under a unit of area of any part of the sea would afford a measure of the productive capacity of that part.

It remained to find some means of making such determination. After much labor Hensen finally adopted the method of drawing a net vertically from the bottom to the surface. Such a net strains out the plankton contained in a vertical column of water and catches the whole amount of plankton under an area of the surface equal to the net opening. From the plankton so obtained the total plankton of the water under consideration may be calculated and the results expressed in volumes or by weight or by enumerating the contained individuals. The productive capacity of a body of water, as expressed in its plankton production, may thus be compared to that of other bodies of water and so may be made of practical use.

The method which Hensen used in the sea was later extended by Apstein, his pupil, to fresh water. Apstein's results were published in various special papers and finally collected into a single very useful volume.[1] This method, with some slight modifications, has since been used in this country by Reighard,[2] Ward,[3] and others.

The great advantage which this method enjoys over others is that the water from which the net strains the plankton is a vertical column extending from bottom to surface, and is thus a representative sample of all the water from all depths in the lake examined. This column of water bears the same relation to the whole body of water that a sample removed from a sheet of metal by a punch bears to the whole sheet. There is no other method applicable to all conditions which has been shown to have this advantage.

There are, however, certain difficulties in the use of this method. These were known to Hensen and he attempted to obviate them. The net does not, as a matter of fact, filter the whole of a column of water through which it passes. A part of the water is pushed aside and a part filtered. By an elaborate set of experiments Hensen tried to determine what part of the water was pushed aside. This depends upon the form of the net and upon the material of which it is made. If the net filters half of the column of water, then in order to know the amount of plankton actually in the column it is necessary to multiply the amount of plankton taken by two. The number by which one must thus multiply is known as the coefficient of the net. The coefficient of the net was assumed by Hensen to remain practically constant. There are, however, two factors which may cause a change in the net coefficient—clogging of the net by foreign particles and shrinkage of the net cloth so as to diminish the size of the openings in it. This change in net coefficient is the first difficulty in the use of Hensen's method. If the pores of the cloth (No. 20 bolting-cloth) used for such nets become clogged the net will filter less water than before, i. e., its coefficient will become greater. If the net coefficient thus changes, the results obtained with a given net at different times, or by different observers with different nets, can not be accurately compared, and a large part of the advantage of the method is lost. It

[1] Apstein, C. Das Süsswasserplankton. Kiel, 1896.

[2] Reighard, Jacob. A biological examination of Lake St. Clair. Bulletin of the Michigan Fish Commission, No. 4.

[3] Ward, H. B. A biological examination of Lake Michigan. Bulletin of Michigan Fish Commission, No. 6.

customary in order to prevent clogging to wash the net at the end of each haul with a stream from a hose. It was further suggested by Hensen,[1] who recognized the effect of clogging on the net coefficient, that the net be more thoroughly washed at the end of each day's work. Hensen[2] and Frenzel[3] have more recently suggested other methods of cleaning the net.

The change in the net due to shrinkage of the cloth and consequent narrowing of the pores does not seem to have been noted by Hensen. It was first pointed out by Reighard.[4] Both causes of change in the net coefficient have been since studied by Kofoid.[5] He finds that owing to clogging of the net "the coefficient of the net varies with the amount and constitution of the plankton from 1.5 to 5.7," and that "from 84 per cent to 96 per cent of the 30-meter catch is taken in the first 15 meters of the (horizontal) haul." Kofoid finds further that from the shrinkage of the net "the total area of the openings in a square centimeter . . . decreases over 50 per cent."

The first difficulty in using Hensen's method, that arising from change in net coefficient, owing to clogging and shrinkage, seems at first sight to be sufficiently serious. The second difficulty is that the openings in the cloth, although very minute, are still so large that some of the organisms of the plankton pass through them and are lost. After correcting the "catch" by multiplying by the net coefficient, the result still does not express the total amount of plankton present in the column of water through which the net was drawn. This source of error was known to Hensen,[6] but he does not appear to have determined the extent to which the smaller plankton organisms pass through the net. Kofoid[5] has now called attention to this subject and has determined for certain forms the percentage of loss from this source. He finds that "of Codonella as many as twenty-one individuals may escape to one retained" and that there is a great loss of other small organisms. Kofoid adds, referring to his predecessors, that, "the leakage of the plankton through the silk has been minimized or ignored and without tests of the extent to which it occurs." An active purpose on the part of plankton workers, such as is implied in the phrase "minimized or ignored," is nowhere evident in the literature. The truth is rather that Kofoid's predecessors have omitted to investigate this source of error quantitatively.

Though neither the variation in the coefficient of the plankton net nor its penetrability to the smaller plankton organisms were discovered by Kofoid, he has rendered important service in pointing out their extent.

It remains to consider to what degree the errors due to the above causes detract from the value of the results hitherto obtained by the Hensen method. The plankton catches thus far made by this method (as by others) have been utilized principally in two directions:

I. They have been measured in order to determine the volume of plankton present in the water. For this purpose the plankton is concentrated, either by allowing it to settle in a graduated cylinder or by the use of the centrifuge, and the volume is then read off. This method is not accurate; it is merely the best method hitherto devised for the purpose. The plankton, which is thus measured, consists of large and small organisms, and as it settles the smaller organisms are mostly packed between the

[1] Hensen. Bestimmung des Planktons, p. 13.
[2] Hensen. Bernerkungen zur Plankton Methodik. Bio. Centralblatt, XVII, 1897, p. 510–512.
[3] Frenzel. Zur Plankton Methodik. Bio. Centralblatt, XVII, 1897, p. 364–371.
[4] Reighard. Loc. cit., p. 59.
[5] Kofoid. On some important sources of error in the Plankton Method. Science, Dec. 3, 1897.
[6] Hensen. Die Bestimmung, etc., p. 10. sec. 3, and p. 75.

larger, but being lighter, are in part deposited in a thin layer on the top of the mass of larger organisms. We may consider separately the errors which are introduced into the volumetric method from the three sources above mentioned.

(*a*) *Errors due to clogging of the net.*—This depends principally upon the area of the filtering surface of the net as compared to the volume of plankton present in the water. If the net surface is large and the volume of plankton in the water filtered small, there is but little clogging. The net employed by Kofoid was 25 cm. in diameter at the base and 40 cm. on one side. The plankton appears to have been unusually abundant (Kofoid gives no data) and the conditions otherwise unsuited to the use of any sort of net. The net employed by Reighard and Ward in the work above referred to had a diameter of 60 cm. and a slant height of 100 cm. Its filtering surface was thus about six times that of the net used by Kofoid, while the plankton in the water in which it was used was very little. In the work done by Reighard not more than 4.5 c.c. of plankton was taken in the net at one time and in the work of Ward not more than 11.9 c.c. In a majority of the hauls not more than a fraction of these volumes was taken. The net used by Hensen was much larger (Hensen, loc. cit., p. 6), while that used by Apstein was about the size of Kofoid's net, but it was probably used under more favorable conditions. Clogging, then, does not seem to me to be an important factor with nets of the size used by Hensen, Reighard, and Ward. It becomes important only in case a small net, such as Kofoid's, is used under unsuitable conditions. Some measure of its extent is desirable.

(*b*) *Error due to shrinkage.*—This error is largely if not wholly eliminated by previous thorough shrinking of the net. The cloth used by Reighard and Ward was several times dampened and ironed before it was made up into the net and was thus presumably thoroughly shrunken. The net was also many times wet and dried before it was used for quantitative work. As may be seen from the table on page 57 of Reighard's report, the cloth of the net used by him and later by Ward differed but little after a summer's use from new cloth which had been once wetted and then dried; the cloth in the two cases being measured under as nearly as possible the same conditions. Whether the nets of other workers were similarly shrunken before use does not appear. I have not encountered any such enormous shrinkage as that recorded by Kofoid, in which the average size of net openings was reduced from .000024 to .00001 sq. cm. Everything here depends on a uniform method of measuring the cloth.

(*c*) *Errors due to permeability of the cloth.* A large number of the smaller plankton organisms escape through the pores of the cloth. According to Kofoid "the silk net retains from $\frac{1}{2}$ to $\frac{1}{15}$ of the total solid contents of the water." "The amount escaping through the silk bears no constant relation to the amount retained." These statements are certainly very startling, but one must reserve final judgment concerning them until the conditions of the experiments upon which they rest are made known. This degree of leakage through the net may be due to the peculiar constitution of the plankton examined. The extent to which this source of error vitiates previous work can only be determined by tests of the nets used by previous workers in comparison with other methods and in the waters in which the nets were used. In volumetric determinations most of the smaller plankton organisms are packed between the larger organisms in such a way as not to affect the total volume of plankton in the measuring tube. Some of them, however, remain in suspension longer than the larger and heavier organisms, and when they settle lie at the top of the whole mass measured, and so increase its volume.

On the whole, one may say that where nets of sufficient size have been used under favorable conditions there is no good reason for assuming that the volumetric results obtained by Hensen's method are vitiated by the first two sources of error noted above. To what extent they are vitiated by the third source of error (leakage) remains to be determined. Since the organisms which escape are the smallest in the plankton, they may be volumetrically of little importance. Their importance depends upon their abundance, and this must be investigated by other methods. When the considerable variations in the volume of the plankton itself are taken into account it seems improbable that the error arising from leakage is sufficient to seriously vitiate volumetric determinations by the Hensen method or their use for practical purposes.

II. The catches made by the Hensen net have also been used for enumerating the number of organisms contained in them. Of the three sources of error above enumerated the first two affect this method to the same extent that they affect the volumetric method, so that by using suitable nets properly shrunken these two sources of error may be avoided here also. The third source of error, that arising from permeability of the net, is, however, fatal to the method of enumeration, in so far as it is applied to smaller organisms. In the tables of Apstein and Hensen, then, the enumerations of smaller organisms can not be accepted as final until it is shown that these organisms can not escape through the net in considerable numbers.

For determining the productive capacity of a body of water use has been made of the volumetric method only. Where the net used has sufficient filtering surface, and where it is not attempted to use the net in situations to which it is unsuited—i. e., among water-plants and in silt-laden waters—it seems to me that this method is not only practicable, but it is the only practicable method hitherto devised, since it is the only method by which the plankton may be obtained from a representative sample of the entire body of water. It should be noted in this connection that the variations in the plankton itself are far greater than the errors of the method.

We may now consider the substitutes that have been offered for the Hensen method. By this method the plankton is removed from a measured quantity of water which remains in position in the lake. We may analyze this procedure into two processes—the measuring of the water and the obtaining of the plankton from the water. For each of these processes, as carried out by the Hensen method, one or more substitutes have been proposed.

Owing to the inconstancy of the net coefficient due to clogging and shrinkage, it may be a matter of uncertainty as to how much water the net actually strains. To obviate this difficulty it has been proposed by Kofoid (loc. cit.) and by Frenzel[1] that the water to be examined should be pumped through a hose. Water from any desired depth may thus be brought aboard the boat and plankton then removed from it by the Hensen net or other means. It is obvious that by this method the quantity of water obtained may be known with exactness, so the difficulty connected with net coefficient vanishes. By the Hensen method the column of water from which the plankton is obtained extends vertically from the bottom to the surface. This column includes equal volumes of water from all depths and is representative of the whole lake. It does not seem to me possible to obtain a representative sample of the water of the lake in any other form than that of a vertical column extending from

[1] Frenzel, Joh. Zur Plankton Methodik, I, Die Planktonpumpe. Bio. Centralblatt, XVII, 1897, pp. 190–198.

bottom to surface. If it is possible to obtain by the pump such a column of water, then the pump may very well replace the net so far as this part of the process is concerned. I do not say that this is not possible, but we should not assume that the water drawn in by a pump through the submerged end of a hose, which is being slowly moved from top to bottom, or vice versa, is a vertical column of water. Before the pump can replace the Hensen net there must be sufficient evidence that this is so, and such evidence is not yet forthcoming.

Having obtained the water by use of the pump, it is necessary to separate the plankton from it. To accomplish this, the second process into which we have analyzed the Hensen procedure, various means have been proposed. Frenzel, and at first Kofoid,[1] made use of the Hensen net to strain the water pumped. In order to avoid the loss of plankton due to the permeability of the net to small organisms, Kofoid later tried various other methods of separating the plankton from the water. These were the sand filter, the filter paper, the centrifuge, and the Berkefeld filter. By each of these methods a greater number of plankton organisms is retained than by the Hensen net. (Nothing is said of volumes.) In some cases as much as 98 per cent of the total number of organisms present is retained. By none of these methods is it possible to obtain the plankton from a large volume of water in a short time, and each has besides other disadvantages which are enumerated by Kofoid. In the case of the Berkefeld filter, which was found to be the most efficient method, it was necessary to remove the catch from the surface of the filter with a "stiff brush." The surface of the filter, which is composed of infusorial earth, was thereby disintegrated and the plankton contaminated by the fragments. It is to be hoped that the disintegration is confined to the filter. The large form of the Berkefeld filter (army filter) filters about 2 liters of water per minute. This is a very slow rate of filtration if one has to deal, as is sometimes desirable in plankton work, with a column of water several hundred feet long and perhaps 10 inches in diameter.

The methods which it has been proposed to substitute for the Hensen method are thus seen to be deficient in two ways. For obtaining the water the pumping method is (so far as yet shown) defective in that the source of the water pumped is uncertain. It is not known that the pump can be made to deliver with accuracy the contents of a vertical column of water. For filtering the water the methods proposed, although they remove the plankton organisms more perfectly than the Hensen net, are yet inferior to it in that they are incapable of handling large volumes of water. Is it possible to so modify the Hensen method or to so combine it with other methods as to correct its errors and at the same time retain its good points? Its errors are the variation in net coefficient, due to clogging and shrinkage, and the permeability of the net for small plankton organisms. Its advantages are that it filters a representative vertical column of water, and that it filters rapidly very large volumes of water. Now, if it is possible to measure the volume of water that passes through the net at each haul the difficulties of clogging, shrinkage, and net coefficient at once vanish. I have not made any attempts in this direction, but I see no reason why a small current meter can not be placed within the opening of the plankton net, so as to register the rate of the current of water passing through the opening during each haul. If this rate were known the volume of water passing through the net could be calculated,

[1] Bulletin Illinois State Laboratory of Natural History, vol. V, article I.

and the plankton taken would be that found in this volume of water. No further calculations of any sort would then be necessary.

If it is possible to thus meet the difficulty arising from clogging and shrinkage there still remains the further difficulty due to the leakage of small organisms through the net. The net will have collected the larger organisms from a representative column of water. In order to obtain these large organisms it is desirable that the net should filter a very large volume of water, in some cases many cubic meters. In order to obtain the smaller organisms it is, however, not necessary to filter so large a volume of water; a few liters would probably suffice. Water for this purpose might be obtained by the pumping method or perhaps quite as satisfactorily by the well-known method of using flasks so arranged that they can be filled after being lowered to desired depths. It would be necessary to take small samples of water from several different depths and to remove the plankton from them by some one of the methods described by Kofoid as retaining the smaller organisms. The objection to this double method is that while it is entirely accurate for the large organisms taken by the net from a vertical column of water, it does not give us the smaller organisms from the whole of this vertical column of water, but rather from isolated samples of water from different levels. It seems to me, however, that if we know the large organisms in a vertical column of water, and if we know also the ratio of the larger to the smaller for certain parts of the column, we may readily calculate the volume or number of small organisms in the whole column. This volume may then be added to that obtained by the net and the total volume thus obtained.

In conclusion, it seems to me that the errors of the Hensen method, the extent of which Kofoid has pointed out, are probably greatly exaggerated by the condition under which he has used the method. This Kofoid himself suggests. The originator of the method probably never intended that it should be used among water-plants and in silt-laden waters. For such waters, which are shallow, the pumping and filtering methods described by Kofoid are undoubtedly best adapted. On the other hand, these methods are by no means so well adapted to deeper and larger bodies of water. For these it seems to me the Hensen method must still be retained, and if it can be modified as suggested above, it may be of value in such waters as those of central Illinois. Whether or not it can be modified in the way suggested, it can at least be supplemented by a method by which the smaller organisms may be more perfectly obtained.

Even in its present form the method is probably sufficiently accurate under most circumstances for the purpose of making rough determinations of the relative productive capacities of different bodies of water. It must be remembered that the method as used for this purpose is at best rough, but it must also be remembered that the variations in volume of plankton are considerable, so that the errors in method are probably within the variations in the material upon which it is used.

ZOOLOGICAL LABORATORY OF THE UNIVERSITY OF MICHIGAN,
*Ann Arbor, Michigan, January 16, 1898.*

# THE IMPORTANCE OF EXTENDED SCIENTIFIC INVESTIGATION.

By H. C. BUMPUS, Ph. D.,
*Professor of Comparative Anatomy, Brown University.*

We meet here as members of a government that within less than three decades has not only revolutionized the methods of fish-culture, but has preserved to its several States, inland as well as seaboard, an industry yielding an annual income of over $45,000,000; a government which now maintains for the propagation of its fishes a fleet of steam and sailing vessels, more than a score of liberally equipped hatching and breeding stations, and which gratuitously issues to those unable to inspect its work a series of publications of great value to practical fishermen, of vast importance to the fish-culturist, and of sterling worth to the scientific world. The names of Baird, Verrill, Goode, and Ryder are familiar in every college and university, and their well-worn publications are conspicuous in biological laboratories from Italy to Scandinavia, and from Liverpool to Tokyo. Abstracts from reports of the United States Fish Commission form a considerable proportion of the last annual of the British laboratory at Plymouth, England, and other governments have frequently sent commissioners to inspect our hatcheries and acquaint themselves with American methods of work.

We should be careful, however, lest the consciousness of a successful past act as a sedative for the present. The lines of research wisely indicated by the founders, I might rather say founder, of American fish-culture should be assiduously followed, and the bypaths explored. The excellent reports of the one lately in charge of the Division of Fishery Methods and Statistics of the Commission—the secretary of this Congress—give an annual guarantee of the work actually accomplished and prove beyond peradventure that the Commission is not only self-supporting, but that the fisheries under its assistance are of rapidly increasing importance.

The introduction of the shad into the Pacific has yielded an average income of approximately $20,000, and the shad industry of the Atlantic, an industry yielding $2,000,000 annually, owes its continuance, if not also its existence, to the efforts of the United States Fish Commission. The planting of cod fry upon the coast of New England has replenished the waters of the east, and it is a fact that the fish were so plentiful in Narragansett Bay during the past autumn that nets could not be drawn, and the neighboring markets became overstocked.

The intelligent propagation of the cod rests upon the scientific work of Professor Ryder. Successful shad raising is largely due to the researches and devices of Commissioner McDonald. The life-history of the oyster was practically unknown until worked out by Professor Brooks. The migrations of the menhaden were unexplained before the researches of Dr. Peck. The work of Professor Libbey bears directly upon the question of distribution of the mackerel, and I venture to predict that successful

sponge-culture will follow upon the continuation of the work begun at Woods Hole by Prof. H. V. Wilson. A continuance of these and similar lines of research is an absolute necessity for the growth and development of the more immediately practical work of propagation and distribution.

The collection and distribution of seeds is not the only function of the Department of Agriculture. This Department maintains a corps of scientific workers at home and abroad, and there is not a State, county, town, or hamlet that is not directly benefited by the results of its organized system of acquiring and diffusing knowledge. The efforts of the United States Fish Commission have been along similar lines and have yielded grand results, but the possibilities of the development of the fish industry have scarcely been indicated.

For some years the starfish have wrought havoc among the oysters of the colder water of our coast. The fishermen have laboriously "mopped" the "beds" with tangles of cotton waste, but have remained quite ignorant of the life habits of their enemy. A brief scientific study of the subject, however, has revealed many facts which point toward a possible, if not a probable, early correction of the evil. It has been found that the young, almost microscopic, gather in a narrow band along the shore, hidden in the eelgrass, where they may be killed off by the thousand with little labor and slight expense. Each oysterman, quite unwittingly, has been actually supporting, immediately around his oyster-bed, a nursery for the propagation of his enemy, the starfish.

In one direction in particular there is crying need of both extended and extensive scientific research. I refer to a matter that received some attention at the Chicago congress, namely, that research which shall result in the *development of the market* for food-fish. I think I do not overstate the fact when I say that there should be three times as much fish consumed as is consumed at the present time. The problem is not alone how shall we produce more fish, but how shall we improve the industry by providing a better and a more stable market for what is already produced. I feel that the fisherman and the fish-dealer are in a measure responsible for the fact that the average American can not endure fish oftener than one day in seven, and were it not for a wise provision of the church perhaps one day in seven would be far too frequent. While the dressing and shipping of meat and poultry has become almost an art, the methods of dressing and handling fish are crude in the extreme.

The abuse of fish as an article of food begins at the moment it is captured and extends to, and often beyond, the kitchen. I need not relate the rough handling on board the smack, the careless packing, and the slovenly condition of our markets; these are all prejudicial to the consumer as well as to the fish; but I wish to emphasize the fact that they are also sources of great loss to the dealer.

The blood that is ordinarily allowed to remain in the fish is the very medium that the bacteriologist uses for the culture of microbes, and its retention in the body of the fish provides the very medium in which the germs of decay delight. Should the fisherman bleed the fish immediately on its capture he would do much toward its reaching the consumer in a healthy condition.

The digestive organs of the fish are very active, and its processes of digestion continue after death; but while before death the contents of the alimentary tract are alone acted upon, after death the digestive ferments attack the surrounding tissues, and they attack these tissues with great energy. A few minutes is often sufficient

for the deterioration of the flesh immediately inclosing the abdominal cavity. It would be a great saving to the dealer if the fish could be disemboweled and thoroughly washed as soon as captured.

Decay is practically an infectious disease. It is the direct result of the activity of certain microscopic organisms. If these organisms have difficulty in entering the tissue of the fish, or if their activity is inhibited through the application of cold or certain chemicals, the process of decay is retarded. Every time a fish is roughly handled, thrown upon the deck or pitched about as so much offal, walked upon or bruised in any way, the continuity of its flesh is broken and decay germs flood into the rupture. The slightest bruise of an apple or pear results in the formation of a center of decay quite visible to the eye. In the fish the center of decay is not so easily detected by the eye, but it is nevertheless present, and its presence is damaging to the dealer and disappointing to the consumer.

Animal tissue absorbs water very readily, but on the absorption of water it changes its structure, loses its flavor, and rapidly deteriorates. Fish should not be allowed to lie in their own slime on wet floors, or in poorly drained barrels and boxes.

The present method of shipping fish by the use of chopped ice is crude, expensive, and often ineffectual. Poultry, meat, or anything but a fish would find no market if shipped in a similar way. The fish arrive at their destination in a thoroughly uninviting condition, they are reeking with slime and filth, ghastly to the sight, offensive to the smell, and disgusting to the touch.

If the retailer, along the coast as well as inland, can be provided with fish that have been properly killed, skillfully cleaned, and carefully handled he will be in a position to present them to his customers in an attractive form, and the consumer will discover that all fish do not taste alike, which is synonymous with saying, all fish are not equally bad.

While urging that all lines of research already undertaken by the Government should be continued, I would suggest that a definite series of experiments be instituted which shall ascertain the best methods of preparing, packing, shipping, storing, and retailing fish, for I am convinced that improvements are possible along all these lines, and that with improvement the demand for food-fish will be very materially increased. Such an investigation, moreover, is eminently appropriate to the United States Fish Commission, since private enterprise can not be expected to experiment unselfishly for the public good.

This opens up another question: When more improved methods have been devised, how shall these, as well as the innumerable improved methods already familiar to the Commission, be brought to the attention of the fisherman?

There is no school, academy, or college, to my knowledge, in the entire United States which gives even one short course in the economics of fish-culture. There are, however, over 1,000,000 men, women, and children dependent upon the fisheries for their existence. The importance of providing instruction in practical fishery has already resulted in the establishment of schools in Norway, Sweden, Germany, and Japan. Dr. J. Lawrence-Hamilton has indicated the scope and outlined the courses for a Fisherfolk's Free Technical School in England, and the late Professor Goode urged the establishment of similar schools in this country. Though the first purpose of such a school should be to instruct, its laboratory would provide opportunities for research, its field equipment would stimulate investigation, and its existence would

guarantee the collection and preservation of scientific data that would be of incalculable value to the fisherman as well as to the dealer.

It is a fact that at present there is not a single institution along our entire coast where one can observe the habits of our marine animals uninterruptedly throughout the year. There is no place where our biologists may go for a few weeks during the winter or early spring, when the ocean is teeming with animal life. The summer months are as the autumn to marine forms, and he who would study ocean life at its best must work in the early spring. The organization or individual that accomplishes the establishment of a permanent institution where instruction in practical fish-culture and fishery economics can be given; where apparatus is provided for the investigation of the lakes, rivers, and sea; where naturalists from our universities and commissioners from our States will be welcome at all times of the year, and where problems of scientific and economic interest can be studied and solved, will obtain what Baird, Goode, and Ryder saw in the distant future, and will combine and control the purely practical and the purely scientific. The need of American biology to-day is the same as the need of successful fish-culture—coordination, cooperation, and the establishment of a station, or the devotion of a station already established, like that at Woods Hole, to instruction and to extended uninterrupted scientific research.

PROVIDENCE, RHODE ISLAND.

# THE UTILITY OF A BIOLOGICAL STATION ON THE FLORIDA COAST IN ITS RELATION TO THE COMMERCIAL FISHERIES.

By SETH E. MEEK, Ph. D.,
*Assistant Curator of Zoölogy, Field Columbian Museum.*

There seems to be considerable disposition of late years on the part of some individuals and institutions of learning to establish biological stations in different parts of the world. Some of these stations are permanent, others only temporary; none, I believe, on our own coast are open during the entire year. They are largely established to supplement biological study in our colleges and universities and to facilitate and promote original research. In none except the Woods Hole Government Station are there any special attempts to solve problems of economic importance.

The scientific work done in these is fragmentary in character. Each investigator continues his particular line of work, with no special reference to its bearing on other problems. The investigator's mind is not troubled as to whether or not the results of his studies will give to anyone the means of securing wealth or be of economic importance to the general public. He is solving, so far as his ability and facilities will permit, some purely scientific problem, without any special interest as to what practical use may be made of its solution.

In our own country, and in this so-called practical age, there is always an attempt to make some practical use of every discovery. The brains of our inventive genius are strained to their utmost to turn new facts into common use; to make scientific discoveries things of commercial utility. In Franklin's time no one ever dreamed that electricity would serve the commercial world as it is doing to-day. Hardly had the discovery of X-rays been made known when thousands were racking their brains to find in them as many methods for their practical use. So far has this idea of utility been developed in this country with regard to the physical sciences that every new fact must in some way serve mankind. This feature is not so prominent in the biological sciences, though much has been done in this direction, especially in medicine and in the propagation of many of our useful plants and animals.

The mapping of the life zones of North America, as begun some few years ago by our Agricultural Department, is already asserting its usefulness. These zones are based on a careful study of the geographical distribution of our land plants and animals, their life-histories and interrelations. This same kind of work must also be extended to our waters, from which we receive such a delicious and abundant supply of food. Observations to this end must be frequently made and constantly carried on during the entire year and under favorable circumstances. Our knowledge of the marine animals which we use for commercial purposes is far too limited. Much infor-

mation concerning their geographical range, breeding places and habits, migrations and laws governing the same, is very meager and indefinite. On the other hand, there are thousands of other animals upon which these are more or less dependent, concerning the life-histories of which we know nothing.

The work done in our present marine biological stations is worthy of high commendation, and any effort to establish other stations should be encouraged. As I have remarked, these stations are established only to afford students an opportunity to study fresh marine forms and to promote and facilitate research purely scientific.

It seems to me that the time is now ripe to establish on our coast Government biological stations, whose objects should be not only to encourage, aid, and promote scientific research, but also to devise means to turn into practical use, as far as possible, all of our knowledge of marine life. These stations should give especial attention to the study of the geographical distribution of all animals, their migrations, and laws governing the same—in fact, everything which bears on their life-histories and their interrelations.

These stations should maintain each a dozen or more tables for the use of investigators from time to time from our various educational institutions. These tables should be used only by men who had already demonstrated their ability to do research work of a high character, and whose purposes at the station were clearly defined. In this respect I would suggest that the policy of the zoological station at Naples be largely followed. This station is the most perfect, and from a scientific standpoint the most useful, of any in the world. It has been in existence a little more than twenty-five years, and its privileges have been used by many investigators from all civilized countries. It is in possession of more information concerning the life of the Bay of Naples than is possessed of a like extent of sea by any other institution. It is strictly a scientific institution, and in this respect has been eminently successful. Its success is largely due to the facts that it is open during the entire year and that its privileges are used only by a high grade of scientific men. A station of like nature established somewhere on the Florida coast, and which would combine the additional feature of the solving of biological problems which have a direct bearing on the commercial products of the sea, is a greatly needed institution, and should, I believe, be largely maintained by our Government and controlled by our United States Fish Commission.

The fishery interests of Florida coasts alone are steadily becoming of immense importance. Her fishes, oysters, turtles, sponges, etc., are found in the markets of our great inland cities. Concerning the growth of these products we know too little. Concerning the plants and animals upon which they are dependent for food we know far less, and our knowledge of the enemies they encounter while in the sea is very deficient. Our information along these lines can best be increased through the agency of one or more biological stations, as I have mentioned. I have remarked that these stations should be controlled by the Fish Commission. The work for them to do lies strictly within its province. It is partially equipped, both as to men and apparatus, for the work.

The fact that this Congress is attended by representatives of many scientific institutions is a sufficient guaranty of their appreciation of the work of the Commission and their interest in the problems connected with the fishery industries. The solution of these problems must fall to the labors of our trained scientific men, and in the establishment of a Government marine biological station efforts should be made to invite to it

the best talent in the country. In the Naples station tables are supported by Cambridge and Oxford universities. Fellowships are given in these institutions which permit students of excellent record to use these tables, in addition to which each student receives from the university a certain amount of money.

In our own colleges and universities are many undergraduate and graduate students engaged in research work, and who are much hampered because of the lack of material. Some of them, because of the expense in securing the proper material when on the coast, are obliged to abandon indefinitely lines of investigation which they have begun. Many of our leading universities give fellowships to meritorious students. These fellowships give the student special privileges of the university, and from nothing to about $1,500 per year. Often the student is allowed to spend his time in study in some other university, usually abroad, because of the special advantages it offers in his particular line of work. A Government biological station could be established and so managed that it would invite these students to its privileges, more especially that particular grade of students engaged in special lines of work having the most direct bearing on problems of economic importance. In this way the greatest possible results could be attained at a minimum of expense.

We have represented at this Congress the United States Fish Commission, some State commissions, commercial fishermen, sportsmen, and a number of scientific institutions, and I believe it could fulfill no better mission than to in some way encourage our National Congress to supplement its appropriation to the Fish Commission, and urge that it establish and maintain at least one biological station on our southern coast, somewhat after the manner which I have outlined. Its importance and usefulness would soon be appreciated, and I am sure it would be productive of valuable results.

CHICAGO, ILLINOIS.

# TABLISHMENT OF A BIOLOGICAL STATION ON THE GULF OF MEXICO.

By W. EDGAR TAYLOR, Ph. D.,
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The Gulf region has a coast line much longer than any other geographic division he coast States. The Gulf coastal line is nearly 7,000 miles long, while the middle antic States have but 5,400 miles of coast. Furthermore, the Gulf region is at the ural trading focus of a very large geographic section. The United States is ided into three great regions, namely, the Atlantic slope section, east of the Appa- ian system; the Pacific slope section, west of the Rocky Mountain divide; and rdly, the great hydrographic basin of the Mississippi. This immense basin contains -thirds of the area of the United States. Likewise, from the standpoint of foreign de there are three centers, namely, New York, San Francisco, and New Orleans. nce the Gulf States are most favorably located for supplying a large part of the country with marine products.

Again, nature has, for the most part, given the Gulf region a united river system, us giving the great Mississippi basin a fauna and flora intimately and peculiarly nnected with the life of the Gulf region. This great basin offers opportunities not nd elsewhere for a study of life under different climatic conditions. Hence the ablishment of a biologic station on the Gulf of Mexico is not simply of interest to Gulf section, but to the Upper Mississippi basin is of more direct value than a ion on either the Atlantic or Pacific coast.

Our natural-history resources are proportionally greater, considering the fact that attention has been given them, than any other section of our country. The Gulf ion is supplied with an abundance of marine and fresh-water products, including oyster, fish, reptiles, sponges, crustaceans, and others. Among invertebrates the er ranks first in commercial importance. It is extremely abundant throughout entire Gulf section, and constitutes the most prominent fishery product. In 1890 isiana ranked fourth in the list of States in the quantity of oysters gathered from lic reefs, surpassing all the other States excepting Maryland, Virginia, and New ey. Louisiana, Florida, Alabama, Mississippi, and Texas each have undeveloped er interests. Among crustaceans the shrimp is taken on the coast of Louisiana, as, and Mississippi. Crabs of various species are abundant. Several species of fish exist in the waters of the Gulf region, becoming very abundant in Louisiana fields, where they are sometimes collected and marketed.

The economic value of the reptiles inhabiting the Gulf section is greater than in other section. They occur in both fresh and salt water. The crocodile is found lorida, while the alligator occurs in every State of the Gulf coast. Turtle farming arried on in Mississippi, and is being developed in other States, most notably in isiana.

The fishes of the Gulf section are abundant, their great abundance possibly being the cause of the delay in their more scientific propagation. Thus it will be seen that the Gulf section, both from a geographic standpoint and the standpoint of its fauna and flora, is at the natural focus of at least two-thirds of the territory of the United States.

But these are not the only reasons why the Gulf section should favor the study of the biologic sciences. The great problems of the preservation of public health; the prevention of the spread of infectious diseases among both lower animals and man, are in themselves demanding most serious consideration. The scientific study of horticulture and agriculture, recognized in all countries as important, is still more necessary in the Gulf section, where all forms of life are more abundant and difficult to control. Other countries are trying to solve the mysteries of malaria, yellow fever, cholera, and other diseases, and why should not we at least do our part? No country on the face of the globe has greater cause for encouraging scientific investigation and progress. Thousands of other problems of equal importance remain to be solved by careful, painstaking investigation.

The great need of the biologic interests of the Gulf section is a well-directed Gulf laboratory liberally supported. Marine biological laboratories have distinct purposes of their own. Unlike many of the summer schools, they are not designed to give many brief courses, from which students can obtain merely a smattering of a large number of subjects. The biological school confines itself to the pursuit of one branch only, is designed to give thorough work in this line, and the work in these laboratories must not be confused with that of many of the summer institutes. A summer biological laboratory must almost of necessity be placed upon the seashore. The ocean is the great home of life. Some large groups of animals are absolutely confined to the ocean, and others are almost wholly so. Marine life, too, furnishes the biologist with most of the interesting and important problems whose solution is solving questions of wide interest.

So well understood is it that the ocean is the great source of life that it is beginning to be felt that no biologist is to-day thoroughly equipped until after he has had the opportunity of spending more or less time in work with living specimens at the seashore. The marine laboratory has about the same relation to biological work in the schools that the ordinary laboratory has to the text book. We no longer regard text-book knowledge as sufficient for a satisfactory equipment in scientific lines, and it is beginning to be felt with equal force that no biologist is properly trained until practical seashore work has familiarized him with the great ocean and its inhabitants. Students in our schools taking their courses away from the shore can, of course, gain a certain practical knowledge, but a knowledge that ought to be completed by the study of the living specimens in their native haunts. Many departments of zoology indeed can hardly be studied except at the seashore. Embryology and comparative physiology are hardly possible except where living, growing specimens are at hand, and certain types of life can not be satisfactorily studied except alive. The teacher in our public schools is learning that to teach zoology or any branch of biology requires not only text-book knowledge, together with laboratory instruction, but requires actual contact with life as it exists in the ocean. Summer seashore work is fast becoming a necessity for the science teacher who wishes to take high rank.

To the college professor also a marine laboratory offers its own special advantages. He who tries to keep himself in the front ranks among our teachers knows

that he can only do this by carrying on research in some chosen line. Along biological lines it is the ocean that contains the great problems for solution, and there the college professor comes, therefore, to obtain his material and to carry on those researches which he knows are the means of keeping himself abreast with the advanced students of his day. The ocean, indeed, is the great source of supply for most departments of biological work. Hence it is that summer biological schools locate themselves at the seashore and aim at work of the very highest character.

A marine laboratory supplements the college or university, and through these the lower schools. It is here that the student meets representative investigators and fellow-workers. Here he finds out technical methods and carries on quietly investigations which could not be made elsewhere. In every country the marine laboratory has become a need to the student and a guide to scientific economic work.

The entire coast line of Europe has become dotted with biologic stations established by societies, private individuals, or governments, or by the combined efforts of these organizations. As early as 1891 France had at least eight biological stations; Great Britain, five; Austria, Holland, and Sweden, two each; Belgium, Germany, Italy, Japan, and New South Wales, one each. In the main each of these laboratories is liberally supported and supplied with buildings and other equipments. The biological laboratory at Naples has cost in plant alone over $100,000, and is carried on at an annual expense of at least $20,000. The laboratory and fittings of the English station at Plymouth were completed at a cost of over $60,000, raised by subscription. These facts alone are sufficient to attest the efficiency and popularity of these stations in Europe.

Of late years biologists have established marine stations at Woods Hole and Cold Spring Harbor on the Atlantic coast, while Leland Stanford Junior University has a station on the Pacific. In the interior stations have been established by the University of Illinois and Monmouth College, Illinois, and the University of Indiana. Other schools, as well as legislatures and private individuals, have made appropriations for natural-history explorations and discoveries. But so far the entire Gulf section, with its immense geographic and biologic interests, has not a single Gulf station. Shall we longer delay this matter? Are not our interests sufficient to induce this Congress to take steps toward encouraging the establishment of such a station?

A Gulf biological station should supplement the school work being done through the school year, more particularly our State schools and higher schools. Here all these schools may combine equipment and biologic faculties, and otherwise materially aid each other. One of the objects, though not the prime object, of a Gulf biological laboratory should be to give instruction to teachers of the biologic sciences. Throughout the Gulf section, teachers possessing more thorough and more modern training in the sciences are needed. In addition to more advanced work, courses should be given in elementary zoology and botany. These courses should be designed both for the teachers whose knowledge of elementary biology is somewhat slight and for students of higher institutions who may desire to supplement a college biological course with a practical study of marine forms. Each of these courses should be arranged so as to provide the fundamental training needed for a teacher or for independent work of investigation. Hence emphasis should always be placed upon practical work rather than upon class work. A biological laboratory might add much to its usefulness by creating a department of supply. Colleges and high schools are constantly demand-

ing more material for class work, while the lower grades of the primary schools are using natural-history specimens for nature studies. The demand for such specimens has been growing, but such material is costly. The price of this material should be made low in order to stimulate more practical work in our schools. The great good already accomplished by the United States Fish Commission through the Smithsonian Institution is an excellent illustration of what may be done in this direction.

It is customary in connection with these stations to arrange for courses of semi-popular lectures. These lectures are authentic résumés of the most recent investigations, and when published do much toward educating the masses and directing public opinion in proper channels. They create a healthy public feeling in reference to the function of scientific work and the utility of original investigation.

All of the arguments so far advanced are important, but the highest and greatest benefit to be derived from a station must come from its original contributions to our knowledge of biology. The distinctive features of such a station must be its capability for carrying on independent investigation. Private rooms for research should be provided and every facility for research supplied. The station should be a place where investigations are made by people who come together for experiment and mutual assistance. Its work should be of such a character and should attain a reputation such that persons contemplating economic work of a biologic nature will unhesitatingly trust the results of its investigators.

The work of a Gulf biological station should be carried on in connection with similar work of the U. S. Fish Commission. This Commission has for some time had under contemplation the establishment of a laboratory on the Gulf coast, and this Congress, in our opinion, should in every way further this movement. The establishment of a biological station in connection with the laboratory and Fish Commission would offer an especially desirable place for public-school teachers interested in scientific topics; would draw college students desiring to supplement a college course with practical work; attract medical students who feel the necessity of a knowledge of biological subjects in connection with their work; would serve as a distributing point for schools wanting marine forms; furnish college and university men chances to meet and compare notes; would immensely increase the development of all our economic interests, and lastly, would crown all of these advantages by stimulating that highest of all labors—the capable, painstaking, original investigation.

RUSTON, LOUISIANA.

# SOME NOTES ON AMERICAN SHIPWORMS.

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In a Congress like this, where men meet to discuss the means of protecting and increasing the supply of the toothsome products of our waters, a paper on shipworms may seem in strange company. While we wish to preserve and protect most of the products of our waters, these creatures we would gladly obliterate from the realm of living things. We have been studying and combating them for a century and more, but have found no adequate means of counteracting their depredations.

During the summer of 1893, while engaged in observations on the oyster at Beaufort, N. C., for the U. S. Fish Commission, the writer became interested in the various shipworms found so abundantly in the waters of that region, and having made some observations on their natural history he returned for periods during the two succeeding seasons to continue them. The results have been incorporated in a paper on the "Natural History, Organization, and late Development of the *Teredinidæ*," which is almost ready for publication.

Shipworms were favorite objects of study during the eighteenth century, on account of their great damage to the dikes of Holland in 1733 and subsequent years. The contemporaneous observers seem to have been unaware of the observations of Pliny and others in ancient times, and supposed the shipworms were natives of India, whence they had been brought by shipping in modern times. During these times they were considered true worms, and it was not till the time of Cuvier that their molluscan characters were recognized.

Even if shipworms were not recognized to be bivalve-mollusks from their adult organization, it would be easy to determine this fact from a study of the development. They start as eggs which none but a specialist could distinguish from the eggs of most bivalves. In the American forms that seem most abundant, at least in our southern waters, the eggs are cast freely into the water and soon fertilized by the male element. They soon begin to develop, and in our warm southern climate become little free-swimming creatures in three to four hours. As yet these little creatures have none of the distinctive features of the shipworms or even of bivalve-mollusks, but within a day the bivalve shell is acquired. For a few days one can rear the larvæ in aquaria, but after a time the conditions become unfavorable, and they disappear. For perhaps three weeks more, in a state of nature, they lead a free-swimming life, and are gradually transformed into little free-swimming bivalves, almost exactly like the little clam or oyster. But how and where, in nature, this transitional period is passed has not been observed.

The next stage which the writer found were the little bivalves about $\frac{1}{100}$ inch in diameter, crawling over the surface of the wood, in quest of their future homes. Once

they have found appropriate places, they begin to change. One by one the bivalve characters become masked, and the little bivalves are transformed into the very long, worm-like shipworms which are found in wooden structures in salt water the world over.

But along with the transformation the bivalve shell is preserved, though it is much modified as compared with other bivalve shells, and covers only a small part of the head end of the body. With it the shipworm excavates the burrow in the wood in which it lives, and seems equally able to penetrate the hardest or softest kind of wood with equal facility. As the wood is grated away by the shell, the small particles are taken into the digestive canal, and the débris is extruded through the anus; but whether it serves for food in any way is a question in dispute. During its life in the wood at least the larger portion of its nutrition is taken in through the tube which at rest hangs in the water, and consists of small animal, and especially vegetable, organisms. In thinking of shipworms, then, it should be remembered that the wood in which they form their burrows is primarily for their own protection, and that without this protection their long, naked, delicate bodies are defenseless.

At Beaufort all kinds of unprotected wood become literally riddled in a very short time. Two kinds of worms are found there in great and about equal abundance—*Teredo norvegica* and *Xylotrya fimbriata*, whose mode of spawning has been already described. A very small proportion of specimens were of *Teredo navalis*, one of the common European forms, in which the eggs are retained in the gills of the mother during a considerable period of their development, perhaps almost till time for them to set into the wood. It is apparently this last species which the writer has found most abundant in Long Island Sound, though a considerable portion of *Xylotrya fimbriata* were also found.

The breeding season in North Carolina, so far as determined, lasts at least till the middle of August and perhaps throughout the summer. That the latter is true is indicated by two sets of facts. In the first place, individuals were found with ripe sexual products during the early part of August, and the young derived from eggs laid at this time must continue to set till September or later. In the second place, the young were setting in the wood abundantly till the middle of August, a fact which indicates that the same continues to some degree for some time longer. Of course from an economic standpoint, the period during which the wood is attacked is one of the most vital points to discover.

The number of young produced is amazing—estimated in one case, from a single very large female, at 100,000,000—and while the greater part are lost before the setting stage is reached, yet the number that set is very great, and one of the most discouraging features in dealing with shipworms in a practical way. If the spat were of fairly appreciable size and set in but moderate numbers it might be feasible, by the careful removal of all old piles and other old timbers, to sufficiently reduce the number to a minimum. But when, under favorable conditions, over 100 to a square inch set where there is not room for more than one or two to reach maturity, it is easily seen what an excess is always present and how futile it is to try to combat the larvæ before they enter the wood. The practical way, of course, is to prevent their entrance into the wood by protecting the wood with copper paint and sheeting. With small piles and timbers it would seem to be worth while to try various means of keeping the bark on the wood, which, so far as I know, has not been done; for it is well known that as long as the bark is on timbers they are not attacked by shipworms.

Once the shipworm has set into the wood it grows with amazing rapidity in our southern waters. In twelve days it has grown to be an eighth of an inch long, in twenty days about half an inch, and in thirty-six days 4 inches, when it is thousands of times as large in volume as when it sets. It has become sexually mature, and is ready to produce a new generation. How long shipworms may live has never been observed, though it is probable for several years, and that during this time they keep growing if there be room in the wood for growth, though when crowded the individuals become dwarfed. The writer has found specimens of great size of *T. norvegica*, some 3 to 4 feet long, and it is easily seen how destructive may be a few of these individuals which may be almost an inch in diameter. The age of such specimens I have not been able to determine, but it is estimated to be less than two years.

In the colder waters of Long Island the writer has found specimens of both *T. navalis* (?) and *Xylotrya fimbriata*, the former the more abundant. They seem to set most abundantly after the 1st of July, though observations for one season can not be conclusive. The rate of growth is much slower, and it would seem to take twice as long to attain the same sizes as in the warmer southern waters.

The writer in his studies of shipworms has paid most attention to features purely scientific in their interest. Observations of any considerable economic value must cover a variety of localities under different conditions and extend through a period of years—observations which the writer has not had sufficient opportunity to make, and which for our American forms have unfortunately never been made.

MINNEAPOLIS, MINNESOTA.

# AN ECONOMICAL CONSIDERATION OF FISH PARASITES.

By EDWIN LINTON, Ph. D.,
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It is not the purpose of this paper to attempt more than a brief sketch of the subject. Before an exhaustive discussion of the economics of parasitism of fish could be profitably undertaken it would be necessary for us to know a great deal more than we do about the life-histories of the forms which infest fish. All that I shall attempt to do, therefore, will be to gather together in brief space such points as have come under my notice which seem to me to bear on the general thesis of parasites of fish economically considered.

The literature of parasitism as affecting fish, mainly systematic or morphological, is widely scattered through a great variety of publications and in many languages; and on account of the great amount of pioneer work which needs to be done—for only a comparatively small number of species of the fishes of North America have been examined for parasites with care—no compilation is yet possible for the parasites of fishes which could be of such permanent utility as the excellent ones which are being prepared for the Department of Agriculture by Dr. C. W. Stiles relating to the parasites of the domestic animals.

I think it must be acknowledged also, for the present at least, that by far the greater number of species of parasites infesting fishes are of interest to the zoologist alone and do not concern the practical fish-culturist, except as he may be interested in questions which have not yet emerged from the comparatively limited field of scientific investigation into the broader field of practical application. And yet even here it may not be wise to despise the day of small things. Under conditions incident to the work of fish-culture the natural interworking of bionomic relations may be so far disturbed as to give an otherwise insignificant parasite all the importance which attaches to the efficient cause of an epidemic. It is quite within the bounds of possibility for damaging cases of parasitism to arise among the fish of a given fish pond which owe their origin to the casual visit or brief sojourn of a fish-eating bird.

An unusual, though altogether natural, condition of this kind exists in Yellowstone Lake, which has been much written about. It is sufficient to say here that the lake when first discovered contained but a single species of fish—the Rocky Mountain trout—which, it is thought, made its way across the great continental divide by way of a bifurcating stream on Two-Ocean Pass. A considerable percentage of the trout of the lake were found to be infested with a parasitic flesh-worm. Upon a careful examination it was found that this worm, although more commonly occurring in cysts in the body cavity, very frequently left the cyst, and, migrating into the flesh of its host, there developed until it was, in extreme cases, a foot or more in length. This worm was plainly a serious drain on the vitality of its host and doubtless caused the death of large numbers of the trout. The very probable source of infection in this case was shown (No. 12) to be the pelican, which in 1890 frequented the lake in large

considerable moment, and it is desirable that our knowledge of the life-history of the species should be extended. There is some reason for thinking that the final host is a fish-eating bird, although it may be some voracious fish, like the gar.

Dr. H. B. Ward has published some very interesting notes of his observations on the fish parasites of the Great Lakes (No. 18). From an examination of 20 species of lake fish, the total number of individuals examined being 102, 95 of which were infested with parasites, he obtained something over 4,000 Trematodes, 2,000 Acanthocephala, 200 Cestodes, and about 200 Nematodes. Trematodes were obtained from every species examined, and in enormous numbers from the dogfish (*Amia calva*). Cestodes were obtained from 14 of the 20 species, Acanthocephala from 13, and Nematodes from 7. Dr. Ward describes a new Distoma from *Amia calva* (No. 19,) encysted forms of which he finds in the crayfish (*Cambarus propinquus*), thus establishing its life-history. The adult form was found also in the channel catfish, *Ictalurus punctatus*, and the yellow perch, *Perca flavescens*.

I would conclude from the results of Dr. Ward's researches, as compared with what I have had the opportunity to observe, that Trematodes are relatively much more abundant in fresh-water fishes than in marine fishes.

## CESTODA.[1]

My investigations have been mainly on marine fishes, in which I have found the members of this order very abundant, largely, perhaps, because of the predilection which the adult forms appear to have for the spiral valve of the Elasmobranchii. The individual shark or skate is not only an engine of destruction, but a source of infection from which innumerable ova of a variety of cestode parasites issue to become encysted in various animals which serve them for food. There can be little doubt that if the sharks and skates were to be exterminated, or sensibly diminished in number, the aggregate of intermediate parasitism among the teleosts, squids, crustacea, and other food of sharks and skates would be materially lessened. The destruction of the Elasmobranchii, while probably not practicable, would be a disturbance of the balance of nature wholly in favor of the food-fishes.

I find larval forms of two genera (*Rhynchobothrium* and *Tetrarhynchus*), in which the adult forms are peculiar to sharks and skates, very commonly encysted in many species of marine food-fish, such, for example, as the squeteague (*Cynoscion regale*). Of adult forms, while the genus *Dibothrium* is somewhat abundant in cods (*Gadidæ*) and flounders (*Pleuronectidæ*), and tapeworms not unusual in the eel and some fresh-water fish, the vast preponderance is to be found infesting the *Elasmobranchii*. The case of the *Dibothrium* of the Rocky Mountain trout has already been mentioned.

It is very desirable that our knowledge of this important group of parasites be extended, both in the direction of ascertaining what forms are to be found in the fish of our waters and in working out the life-histories of forms already known. It should be remarked that one species of human tapeworm (*Bothriocephalus latus*) is believed to be got from eating the flesh of the European tench.

I take this opportunity of calling attention to a paper by Dr. F. S. Monticelli (Boll. d. Soc. d. Nat. Napoli, Serie I, vol. VIII, Anno VIII, Fasc. I, 1894) *Si Mangiano le Ligule in Italia?* In this paper the author affirms that Leuckart is in error in stating (*Die Parasiten des Menschen*) that in Italy the ligula—a larval form of a cestode worm which develops in the abdominal cavity of certain fresh-water fish and there

[1] See List of Authorities: Nos. 7, 8, and 10 to 16.

attains considerable dimensions—is "eaten as living macaroni." This statement of Leuckart's has been taken without question and repeated in various forms by different writers. Donnadieu (Contribution à l'histoire de la Ligule, Journal d'Anatomie et de la Physiologie 1877) repeats the assertion and adds that many people in Lyons have the same habit. Doubtless the truth is that ligulæ have been eaten along with the fish which harbored them, much as roe is eaten, by persons who did not know the real nature of the tidbit, which no doubt, in the blissful ignorance of the eater, pleased his palate quite as well as did the flesh which was a part of the fish.

### ACANTHOCEPHALA.[1]

The members of this order, so far as my observation goes, are not found in large numbers in many species of fish, although they are likely to occur in great number in occasional individual hosts, particularly among the flounders (*Pleuronectidæ*). The most persistently occurring cases of parasitism which I have observed, however, have been in this order. I have examined the striped bass (*Roccus lineatus*) repeatedly in successive summers at Woods Hole, Massachusetts, and have rarely found an individual which was not infested with a thorn-head worm (*Echinorhynchus proteus*). Sometimes it occurs in considerable numbers, and almost always penetrates with its thorny proboscis the coats of the intestine of its host, thus causing more or less local irritation, followed by a waxy degeneration of the tissues.

There is probably no practical way of counteracting the bad influences of worms of this order, since their larval state is passed, in some cases certainly, and in most cases probably, in small crustacea, which constitute a constant and necessary source of food for the fish. The same remark which was made in another connection with regard to the disposal of the viscera of fish applies here. In no case should the viscera of fish be thrown back into the water. In this order the sexes are distinct, and the females become at last veritable sacs for the shelter and nourishment of enormous numbers of embryos. The importance, therefore, of arresting the development of as many embryos as possible is at once apparent.

### NEMATODA.[2]

The round worms are very abundant, especially in immature stages, in marine fishes. In fresh-water fishes they are probably not so abundant.

I have lately gone over a large collection of nematode parasites of fishes, made in part by myself at Woods Hole, Massachusetts, and in part belonging to the United States National Museum, having been collected in various localities. In this collection there are nematodes from over 60 species of fish. I have noted some 80 distinct kinds, 14 of which have to be recorded as "*Ascaris* species," they being immature, although free in the intestines of their hosts. They plainly belong to the genus *Ascaris*, but do not have distinct characters which will enable one to refer them to species already established or to make it advisable to give them new specific names. At least 40 kinds, from as many specifically different hosts, I have been obliged to refer to a section headed "Immature nematodes, encapsuled, and for the most part belonging to the genus *Ascaris*." It would not be profitable to give names to these immature forms, since many of them are doubtless different stages in the development of the same

[1] See list of authorities: No. 7, pp. 490–498, pl. v, vi; No. 9; No. 13, pp. 555–556, pl. 65–67.
[2] See list of authorities: No. 13, pp. 557–561, pl. 67; No. 14, pp. 111–112.

species. Often in a lot of encapsuled forms, collected at the same time from the same host, individuals are obtained which differ very considerably one from another.

One viviparous species belonging to the genus *Ichthyonema* (which I have referred, with some hesitation, to the species *Ichthyonema globiceps* Rudolphi) on account of the enormous number of young which the adult specimens contain, might, under favorable conditions, become of serious import. I shall speak of it somewhat in detail. The several lots of worms which I refer to this species come from the following hosts:

1. Bluefish (*Pomatomus saltatrix*), ovaries, Woods Hole, August, 1884.
2. Spanish mackerel (*Scomberomorus maculatus*), ovary, New Jersey coast, S. E. Meek, collector, October, 1886.
3. Black grouper (*Lobotes surinamensis*), peritoneum, Woods Hole, August 3, 1887.
4. Black grouper (*Lobotes surinamensis*), viscera, Woods Hole, August 6, 1887.
5. Tarpum (*Tarpon atlanticus*), U. S. Nat. Mus. collection, locality and date of capture not given.

The specimens are all females, and, with the exception of lots 2 and 5, have the uterus, at least its lower portion, filled with embryos. They are all very long and of nearly uniform diameter throughout, and rather bluntly rounded or conical at the extremities. In lot 1 the embryos, which occur in myriads, appear to have escaped by rupture of the uterus into the body cavity. Lot 3 consists of two specimens obtained from the body cavity of their host. They measured living 510 and 580 mm. in length, respectively, and 1.48 mm. in diameter; color, brownish. The intestine appeared as a dark-brown line for more than two-thirds of the entire length and as a white line for the remainder of its length. The intestine ends blindly at its posterior extremity. My notes, made at the time of collecting, state that the external opening of the uterus is at a point about 1 mm. from the anterior end, where it was observed that the young were being discharged in vast numbers. Under slight pressure, however, two tubes were seen protruding for a short distance, from each of which young were escaping. This would appear to indicate that the uterus had been broken, and what was taken to be an external opening may have been a break in the body wall.

The embryos measured about 0.4 mm. in length, 8 $\mu$ in diameter at the posterior end, and 13 $\mu$ in greatest diameter. The anterior end was very slender, appearing as a mere line, even when highly magnified. These embryos are characterized by having a few, about four, dark-brown granular masses scattered along the middle region of the body. A slight notch was noticed at the posterior end of some. A favorite position of these embryos is with the posterior end bent rather sharply, often so much so as to point forward. The anterior end is also often bent so that the two ends point toward each other. Where they occur in the greatest abundance in the parent worm they impart to the latter a plump and even distended appearance. After the discharge of the embryos the worm is transparent, much contracted, quite irregular in outline and in places flattened and shriveled. I do not know what the history of this worm is between the embryos as seen in these specimens and the adult. The embryos are eminently well fitted for making their way by means of their attenuated and filiform anterior ends through the tissues of their host, whatever that host may be. If they have a history anything like that of *Trichina spiralis*, then the animal which would make a meal off of a fish harboring one or more adult *Ichthyonemæ* has trouble ahead.

While encapsuled nematodes were found in a large number of the species of fish examined, and in considerable abundance in some, they were almost always confined to the body cavity, where they lay in flat coils for the most part on and among the viscera. They were very seldom seen in the flesh. The adults in the alimentary canal

in most cases occurred in comparatively small numbers in the several hosts. The only fish in which I found numerous adult nematodes was the swordfish (*Xiphias gladius*). These worms were referred to the species *Ascaris incurva* Rudolphi. They were found in the stomach and were of different sizes, from immature, filiform specimens up to large, plump individuals 250 mm. in length. The largest of which I have any record was 267 mm. in length and 3 mm. in diameter.

I pass over cases of external parasites of fishes, leeches, lerneans (fish lice), etc., as not coming within the proposed scope of this paper.

WASHINGTON, PENNSYLVANIA.

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*Partial list of American authorities on fish parasites, especially such as have been published by the U. S. Fish Commission and the U. S. National Museum.*


PROTOZOA.

1. On certain wart-like excrescences occurring on the short minnow, *Cyprinodon variegatus*, due to psorosperms. Edwin Linton. Bulletin U. S. Fish Commission for 1889, pp. 99–102, pl. XXXV.
2. Notice of the occurrence of protozoan parasites (Psorosperms) on cyprinoid fishes in Ohio. Edwin Linton. Bulletin U. S. Fish Commission for 1889, pp. 359–361, pl. CXX.
3. On the classification of the Myxosporidia, a group of protozoan parasites infesting fishes (issued July 15, 1893). R. R. Gurley. Bulletin U. S. Fish Commission for 1891, pp. 407–420.
4. Report on a parasitic protozoan observed on fish in the Aquarium. C. W. Stiles. Bulletin U. S. Fish Commission for 1893, pp. 173–190, pl. 11, 12.
5. The Myxosporidia, or psorosperms of fishes, and the epidemics produced by them. R. R. Gurley. Report U. S. Fish Commission for 1892, pp. 65–304, pl. 1–47.

HELMINTHA.

6. On a skin parasite of the cunner (*Ctenolabrus adspersus*). John A. Ryder. Bulletin U. S. Fish Commission for 1884, pp. 37–42.
7. Notes on entozoa of marine fishes of New England. Edwin Linton. Report U. S. Fish Commission for 1886, pp. 453–511, pl. I–VI.
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9. Notes on entozoa of marine fishes, Part III. Edwin Linton. Report U. S. Fish Commission for 1888, pp. 523–542, pl. LIII–LVIII.
10. The anatomy of *Thysanocephalum crispum*, a parasite of the tiger shark. Edwin Linton. Report U. S. Fish Commission for 1888, pp. 543–556, pl. LXI–LXVII.
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13. On fish entozoa from Yellowstone National Park. Edwin Linton. Report U. S. Fish Commission for 1889–1891, pp. 545–564, pl. 63–67.
14. Some observations concerning fish parasites. Edwin Linton. Bulletin U. S. Fish Commission for 1893, pp. 101–112.
15. Notes on larval cestode parasites of fishes. Edwin Linton. Proc. U. S. National Museum, vol. XIX (1897), pp. 787–824, pl. LXI–LXVIII.
16. Notes on cestode parasites of fishes. Edwin Linton. Proc. U. S. National Museum, vol. XX (1897), pp. 423–456; pl. XXVII–XXXIV.
17. Notes on trematode parasites of fishes. Edwin Linton. Proc. U. S. National Museum, vol. XX (1897), pp. 507–548; pl. XL–LIV.
18. Some notes on the biological relations of the fish parasites of the Great Lakes. (Abstract.) H. B. Ward. Proceedings of Nebraska Academy of Science, IV, pp. 8–11. 1894.
19. Notes on the structure and life-history of *Distoma opacum*, new species. H. B. Ward. Proceedings of American Microscopical Society, vol. XV, pp. 173–182, with plate.

# THE FISH FAUNA OF FLORIDA.

By BARTON WARREN EVERMANN, Ph. D.,
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There is perhaps no State in the Union whose fishes have attracted more general ttention than have those of Florida. The interest in the fishes of this State is hared by the commercial fishermen, the angler, and the ichthyologist. The number f species that are sought because of their commercial value is far greater than in ny other section of America. Those that are of interest to the angler are more umerous than any other State can boast, while the richness and peculiarities of the sh fauna of Florida have made this State a fascinating field to the ichthyologist and tudent of geographic distribution.

Before entering upon the detailed discussion of the fish fauna let us notice for a ioment a few of the more important geographic and cl matological factors of the tate, for these are the features which determine the character of the fish fauna of ny region.

Florida is the most southern of all the States, the entire State lying south of the hirty-first parallel. Its most southern point is in latitude 24° 30′, about 1° 30′ arther south than any other point of our territory. In longitude it extends from he eightieth meridian to that of 87° 30′. It will be thus seen that the State extends hrough 6½ degrees of latitude (nearly 400 miles) and 7½ degrees of longitude (or bout 400 miles). It has relatively and actually by far the greatest shore line of any tate, the total being not fewer than 1,200 miles, or more than 1 mile of shore line or every 5 square miles of territory—in fact, about 230 more miles of sea front than it ould have if it were a square island.

Though Florida has not the diversified geographic features possessed by many other tates, such as Georgia, which give it mountain torrent, upland river, and lowland arsh, nevertheless its numerous lakes and rivers are not without variety. Some of ie streams are more or less turbid, some clear and cold, others temperate, and others arm. All are rich in water vegetation, which invariably implies a rich fauna as well, nd the vast Everglades present conditions hardly to be duplicated elsewhere in merica.

The more than 1,200 miles of coast line present great diversity as to nature of iore and temperature of water. There are to be found on the Florida coast almost ıy kind of shore one may desire; vast areas of mud flats in some places, long reaches clean sand and shallow water in others, rocky shores with shallow tide pools, a ultitude of narrow, shallow channels and mangrove islands, and the great chain of lorida Keys, among which a wide diversity of conditions is found, such as great mud ats, large fields of algæ, forests of gorgonians, great sponge-grounds, coral reefs, c., not duplicated anywhere on our coast.

From the relatively cool waters of Pensacola and Fernandina the temperature gradually rises southward until we reach the Keys, where it becomes noticeably higher on account of the Gulf Stream as it sweeps through the Florida Straits and up the eastern coast. Nowhere else on our coast is the influence of the Gulf Stream so great, and nowhere else does the fauna of tropical seas extend so far north. Indeed, among the Florida Keys we find the nearest approach to tropical conditions to be found anywhere in the United States.

It is remarkable that the rich fish fauna of Florida did not attract the attention of students earlier than it did. Prior to 1870, scarcely anything was known concerning the fishes of the State. So far as we have been able to learn from an examination of ichthyological literature the earliest references to Florida fishes are those of Mark Catesby in 1754, LeSueur in 1824, and Holbrook in 1855 and 1856. Catesby's Natural History of Carolina, Florida, and the Bahama Islands, a mammoth work of two volumes, royal folio, with 220 colored plates, contains a few references to Florida fishes, but this was before the beginning of binomial nomenclature (which dates from 1758), and no names were given. In 1824 Messrs. Maclure, Say, Ord, and Peale, of the Philadelphia Academy, all great men in the early history of science in America, made a trip to Florida and brought back with them dried specimens of one ray and one skate. These were described in the same year by LeSueur as *Raia sabina* and *Raia desmarestia*, but are now known as *Dasyatis sabina* (one of the most common rays on the Florida coasts) and *Raja eglanteria*, the brier skate, less common than the other species. These, so far as we have been able to learn, are the first fishes ever described from Florida localities.

In 1856 Dr. John Edward Holbrook published an "Account of several species of fishes observed in Florida, Georgia, etc." In this paper 6 species were credited to the St. Johns River, 5 species of sunfishes and 1 darter, all of which were described as new, but not one of which proved to be so. In 1855 Holbrook published the first edition of his Ichthyology of South Carolina, and in 1860 the second edition of the same work appeared. In this work 12 species are referred to definite Florida localities in the first edition and 22 in the second, one of the latter (*Esox ravenelli=Lucius americanus*) being described as new.

In the twenty years following the appearance of the first edition of Holbrook's Ichthyology little or nothing was added to our knowledge of the fishes of Florida. Not until 1878 was any serious or considerable study made of the fishes of this State. In that year Mr. Silas Stearns, of the Pensacola Fish and Ice Company, began sending specimens of Florida fishes to the U. S. National Museum. The first specimen was described by Goode & Bean as the type of a new species, the blanquillo (*Caulolatilus microps*), a near relative of the noted tilefish, whose sudden appearance in myriads in the Gulf Stream about the same time and whose as sudden disappearance in 1882 remain to this day among the marvels of the natural history of fishes.

In the winter of 1877–78 Mr. Stearns began a most active and intelligent study of the distribution and habits of the fishes of the Gulf coast of Florida. Particular attention was paid to the food-fishes and the fishes found on the Snapper Banks. Specimens of the various species were sent to the National Museum, which formed the basis of numerous important papers by Goode & Bean, Jordan, and Stearns.

I wish to call special attention to the work done by Mr. Stearns. It was of very great importance and deserves more than a passing notice. During the few leisure hours of an active business life Mr. Stearns found time to make a study of the natural

history of the fishes of the Gulf coast which even to this day constitutes the bulk of our knowledge of many of the species of that region. He made invaluable collections, containing many species new to science, and his own direct contributions to the literature of Florida fishes, published in the Fishery Industries reports of the Tenth Census, may well serve as models for writers on natural-history subjects. The untimely death of Mr. Stearns in 1888 was a severe loss to science as well as to the State of Florida.

Since 1878 a number of persons have done more or less collecting in Florida; among them the following may be mentioned: Dr. J. W. Velie, in Clearwater Harbor and vicinity; Dr. J. A. Henshall, from Biscayne Bay around the coast to Tampa; Dr. Jordan, at Pensacola, Cedar Keys, and Key West; Dr. O. P. Hay, about Captiva Pass; the vessels of the Fish Commission, at the Tortugas, on the Snapper Banks, and elsewhere along the Gulf coast; Messrs. A. J. Woolman and L. J. Rettger, in the streams of the western part of the State; Mr. Einar Lönnberg, in the fresh waters about Orlando; Mr. Charles H. Bollman and the writer, at Pensacola and on the Snapper Banks; Mr. Barton A. Bean and the writer, in Indian River and Lake Worth; Dr. H. M. Smith, in Biscayne Bay; Dr. William C. Kendall, in the St. Johns River; and Dr. Kendall and the writer, about Biscayne Bay, Key West, Tampa, and Tarpon Springs. The characteristics of the fish fauna of the other portions of the State are almost wholly unknown; and our knowledge of those regions which have received some attention is far from satisfactory. New species and new and important facts about known ones are discovered each time any investigations are made in any part of the State. A vast amount of work remains to be done before we may consider our knowledge of the fishes of Florida even approximately complete.

## THE FISHES OF FLORIDA.

The total number of species of fishes known from Floridian waters is about 600, or about one-fifth of the entire fish fauna of America north of Panama. This number is far larger than can be found in any other section of our country, and is due to the diversity and peculiarities of the climatic conditions already mentioned. The Florida fish fauna may be regarded as made up of at least five more or less distinct faunas: (*a*) the salt-water fauna of our South Atlantic States, (*b*) the subtropical fauna of the Florida Keys, (*c*) the Gulf of Mexico fauna, (*d*) the fresh-water fauna of the southern portion of the Lower Mississippi Valley, and (*e*) the fresh-water fauna of the Everglades.

These, of course, overlap more or less, and in a consideration of the entire fish fauna of America these regions would not be regarded as constituting distinct faunal areas; but for our present purpose they may properly be considered as fairly distinct. From Fernandina southward to Biscayne Bay are found most of the species characteristic of the coast south of Cape Hatteras. From Biscayne Bay to Key West and the Tortugas is found a fish fauna marvelous in its multitude of species and in their richness of coloration.

Among the fishes of this region which deserve special mention are the great numbers of groupers, snappers, grunts, and porgies, all important food-fishes; the many labroid species, such as the hogfish, pudding-wife, and the various parrot-fishes, all remarkable for their brilliant coloration; the many species of pipefishes, the tangs, angel-fish, and chætodonts, among them several of the most gorgeous of American fishes.

The fish fauna of the Florida Keys resembles that of Cuba very closely. Nearly all the food and game fishes at Key West are also found at Havana. The warm waters of the Keys serve as a more or less effective barrier to the passage of fishes living in colder water. As a result many species are found on the east coast of Florida which do not occur on the Gulf coast, and vice versa. There are so many species found on the west coast of Florida that are not known from the east side that the two coasts may be regarded as having separate faunas. This west-coast fauna extends from the "bay" to Pensacola and beyond, and is not essentially different from that found elsewhere on the Gulf coast.

In the fresh waters of the northern part of the State the fishes are essentially the same as occur in the streams and ponds of the other Gulf States, and include several species of minnows, sunfishes, catfishes, suckers, *Amia*, and a few darters. From the little that is known about the fresh-water fishes of the extreme southern part of the State, it is believed that the species are to a large extent distinct and peculiar to that region. There is great need, however, of further investigation in this region.

Of the 600 species of fishes credited to Florida waters about 51 are fresh-water species, 20 may be regarded as brackish-water species, and the remaining 529 constitute the salt-water fish fauna of the State.

## FRESH-WATER SPECIES.

The number of fresh-water species known from the State is not large. They belong to the following families:

| | | | |
|---|---|---|---|
| *Petromyzonidæ* (Lampreys) | 1 | *Pœciliidæ* (Killifishes) | 13 |
| *Lepisosteidæ* (Gars) | 3 | *Aphredoderidæ* (Pirate Perch) | 1 |
| *Amiidæ* (Bowfins) | 1 | *Atherinidæ* (Silversides) | 1 |
| *Siluridæ* (Catfish) | 8 | *Elassomidæ* (Pygmy Sunfishes) | 1 |
| *Catostomidæ* (Suckers) | 1 | *Centrarchidæ* (Sunfish and Bass) | 10 |
| *Cyprinidæ* (Minnows) | 7 | *Percidæ* (Darters) | 2 |
| *Luciidæ* (Pikes) | 2 | | |

Of these 51 species the only ones of commercial importance are the catfishes, pikes, sunfishes, and the large-mouthed black bass. This list is remarkable in that it contains so few of the *Catostomidæ*, *Cyprinidæ*, and *Percidæ*. Each of these is a very large family, the approximate number of species of each in American waters being as follows: *Catostomidæ*, 70; *Cyprinidæ*, 227; *Percidæ*, 88.

The most southern locality in Florida from which specimens of fresh-water species have been obtained is Miami, 8 species having been collected there in the Miami and Little rivers in 1896. Doubtless many additional species will be discovered when the waters of the State are more thoroughly explored. The regions which promise the richest and most important results are the Everglades, the lakes in the interior south of Lake George, and the streams crossing the northern boundary of the State.

## BRACKISH-WATER SPECIES.

In this category may be included all those species which live habitually in brackish water, those more truly salt-water species which are also found more or less commonly in brackish and even fresh water, and also those more truly fresh-water species which are occasionally found in brackish water. In this division will fall, of course, all anadromous and catadromous species, such as the shad and the common eel. The family

having the greatest number of species in this division is the *Pœciliidæ*, preeminently the family of brackish-water fishes. Florida contains 21 species of this family, of which at least 8 live habitually in brackish water and each of the other 13 may occasionally occur there. This family is worthy of note as containing the smallest known fish, *Heterandria formosa*, which is less than an inch in length.

Two species of shad are known from Florida. On the east coast the common shad (*Alosa sapidissima*) is a common and valued species. It occurs regularly and in considerable numbers in the St. Johns and St. Marys rivers and rarely in the Indian River It is not positively known to occur in any other waters of the State. At Pensacola a few young shad were obtained by Dr. Jordan in 1882 and provisionally identified as a species distinct from the common shad, but no name was given to them and no description published. In the spring of 1896 an unusually large run of shad occurred in the Black Warrior River at Tuscaloosa, Ala., and specimens were sent to the United States Fish Commission for identification. They proved to be different from the common shad and a new and undescribed species, to which the name *Alosa alabamæ* was given by Jordan and Evermann. When studying these specimens I also studied those from Pensacola (now in the United States National Museum) and found them identical with the Alabama shad.

Shad have been reported from various west Florida rivers, particularly the Suwanee, Apalachicola, and Escambia rivers. It is not positively known what species these may be, but it is more than likely that they are the Alabama shad. An actual examination of specimens from these rivers will be necessary to determine the matter, and the United States Fish Commission would be glad to receive specimens from anyone who has an opportunity to collect them.

## SALT-WATER SPECIES.

The great majority of Florida fishes are, of course, salt-water species, there being not fewer than 529 species, distributed among many families and genera. On the east coast approximately 175 species are found, among the Florida Keys 290, and on the west coast about 300. Several important species are found throughout these three regions. Key West is the most important and interesting of all Florida localities as regards the number of species, about 250 species being known from there, of which about 100 are food-fishes of greater or less importance. The richness of Key West in food-fishes will be seen when we recall the total number of food-fishes in each of the other important fishery regions of the United States, as shown in the following list:

| | | | |
|---|---|---|---|
| South Atlantic States | 55 | Pacific States | 40 |
| Middle Atlantic States | 50 | Great Lakes | 16 |
| New England States | 48 | Gulf States (Florida excepted) | 42 |

The more important species handled at Key West are the grunts (6 species), the porgies (5 species), the groupers (8 species), the snappers (4 species), the hogfish, kingfish, Spanish mackerel, the carangoids (8 species), and the mullets (3 species). Besides these there are some 60 or 70 species which for one reason or another are less important but are nevertheless handled to some extent. A great many, perhaps a majority, of the food-fishes at Key West occur also about Cuba and may be seen in the Havana market.

The method of handling fish at Key West is unique, and calculated to conserve the fisheries of that region to the fullest extent. Practically all of the fishing is done with hook and line, and every fishing boat has a well into which the fish are placed. All salable fish are brought to market in the wells of the vessels and kept alive until sold. The prospective purchaser visits the fish wharf, selects from some one of the boats the fish he desires, and it is then killed and dressed by the fisherman. This excellent method insures perfectly fresh fish to the purchaser, and few or no fish are lost or wasted.

There is no other place in the United States where one can study live fishes so satisfactorily as at Key West. Fishing boats are lying at the fish wharf at all times and in their wells may be seen specimens of numerous species, many of them of brilliant coloration; and by going out with the fishermen upon the bars and coral reefs one may, by the aid of a water glass, spend many hours observing and studying a multitude of fishes and other interesting forms as they disport themselves in the clear waters beneath the boat.

## FOOD-FISHES OF FLORIDA.

While the waters in the vicinity of Key West are wonderfully rich in species of fishes used as food, not all the food-fishes of Florida are found there. The shad does not occur there; neither does the black bass nor any of the fresh-water species; nor do we find there, except possibly as stragglers, the spotted sea trout, the red drum, spot, whiting, pompon, flasher, and perhaps still other species known from Indian River. Additional species are known from Pensacola which do not occur at Key West. The total number of different species of food-fish now known to occur in the waters of Florida is approximately 140, divided among 36 different families, as follows:

| | | | |
|---|---|---|---|
| *Acipenseridæ* (Sturgeon) | 1 | *Pomatomidæ* (Bluefish) | 1 |
| *Siluridæ* (Catfishes) | 4 | *Centrarchidæ* (Sunfishes and Black Bass) | 10 |
| *Catostomidæ* (Suckers) | 2 | *Centropomidæ* (Robalos) | 1 |
| *Cyprinidæ* (Minnows) | 1 | *Serranidæ* (Sea Bass) | 10 |
| *Anguillidæ* (Eels) | 1 | *Lobotidæ* (Triple-tails) | 1 |
| *Elopidæ* (Tarpons) | 2 | *Lutianidæ* (Snappers) | 8 |
| *Albulidæ* (Lady-fishes) | 1 | *Hæmulidæ* (Grunts) | 12 |
| *Clupeidæ* (Herrings) | 8 | *Sparidæ* (Porgies) | 12 |
| *Luciidæ* (Pikes) | 2 | *Gerridæ* (Mojarras) | 4 |
| *Esocidæ* (Needle-fishes) | 2 | *Kyphosidæ* (Rudder-fishes) | 1 |
| *Hemiramphidæ* (Balaos) | 4 | *Sciænidæ* (Croakers) | 11 |
| *Mugilidæ* (Mullets) | 4 | *Labridæ* (Wrasse-fishes) | 1 |
| *Sphyrænidæ* (Barracudas) | 2 | *Scaridæ* (Parrot-fishes) | 2 |
| *Polynemidæ* (Threadfins) | 1 | *Ephippidæ* (Angel-fishes) | 1 |
| *Holocentridæ* (Squirrel-fishes) | 1 | *Chætodontidæ* (Butterfly-fishes) | 3 |
| *Scombridæ* (Mackerels) | 4 | *Teuthiididæ* (Tangs) | 3 |
| *Trichiuridæ* (Cutlas-fishes) | 1 | *Scorpænidæ* (Rockfishes) | 1 |
| *Carangidæ* | 14 | *Pleuronectidæ* | 4 |

This large number represents about one-twentieth of the entire fish fauna of America north of the equator.

The value to the State of these commercial fishes will doubtless be set forth in other papers to be presented at this Congress, and need not be dwelt upon here. Suffice to say that the money value of the annual fish output of the State is, in round numbers, not less than $1,000,000.

## THE GAME-FISHES OF FLORIDA.

The fame of the game-fishes of the State of Florida extends throughout America, and beyond. Wherever there are anglers and rod and gun clubs, the prowess of the "silver king" is known and talked about. The one great hope of every angler is that he may go to Florida and kill a tarpon before his fishing days are over. But while the tarpon or silver king is the king of the game-fishes of this State, it is by no means the only game-fish. Some of the largest black bass known have been caught in Florida waters. The sunfishes are the largest of their kind. The ladyfish and the bonefish are thought by many to equal their relative, the tarpon, in real game qualities. Trolling for kingfish, jack, crevallé, bluefish, Spanish mackerel, and spotted sea trout, at Indian River, Lake Worth, Key West, or Biscayne Bay, furnishes sport of the most exciting kind; while still fishing for sheepshead and mangrove snappers at Indian River Inlet; for chubs, porgies, porkfish, yellow-tails, snappers, and grunts at Key West; or for red snappers, red groupers, and others of their kin on the Snapper Banks, furnishes sufficient variety to please any angler, in whatever mood he may chance to be. I have fished in every State and Territory in the Union but three, and from Siberia and Bering Sea to the gulfs of California and Mexico, and, all things considered, regard Florida as unequaled in the richness and variety of its attractions for all sorts of sport with rod and reel.

## THE NECESSITY OF A BIOLOGICAL STATION IN FLORIDA.

The only station for biological research on the coast of the United States which receives Government support is that at Woods Hole, Massachusetts. While it has never received the support which it should, and has never been fully equipped, it has nevertheless been one of the most important centers for biological study in this country. The location is in many regards admirable. In addition to a rich local fauna and flora, many forms of marine animal and plant life are brought there by the Gulf Stream, thereby greatly increasing the variety of life in that vicinity. But the station is kept open only for a few months during the summer, the winters being too severe for satisfactory work.

The ideal marine biological station must be located at some point not only where the local fauna and flora are rich both in species and individuals, but where the climatic conditions will permit investigations and observations to be carried on throughout the year. The region should also be one in which are found in abundance many of the species of animals and plants which are of special interest to biologists, those the study of whose development and life-history will add greatly to our knowledge of the relationships of the larger groups.

There is no other place on our coast where these conditions are so fully met as on the southern coast of Florida. The climatic conditions are all that could be desired. Investigations could be carried on throughout the year. The waters fairly teem with hundreds of species of fishes, mollusks, crustaceans, echinoderms, corals, sponges, marine algæ, and many other groups, while the abundance of individuals of many of the species is marvelous; and, what is of prime importance, many of the species are permanently resident and can be observed and collected at any time throughout the year, thus enabling the investigator to make a study of the complete life-history of the species.

Without even mentioning the numerous purely scientific problems of deep interest to the embryologist which could be studied under most favorable conditions at such a station, I wish to call attention to a few of the many investigations which are sure to prove of great economic importance and which can be conducted here to the best advantage. I may mention the following:

1. The spawning habits of the numerous food-fishes of the coast and the possibility of their artificial propagation.

2. The food of the various species of fishes.

3. The life-histories of the manatee, alligator, crocodile, and the several species of turtles, and the development of methods for increasing their commercial value.

4. Experimentation regarding the artificial cultivation of the commercial sponges.

There is not a marine species of Florida fish whose life history is fully known. We are ignorant of the habits of even the most common and important species. Take even such an important fish as the pompano; we know absolutely nothing of the time, place, and manner of spawning, the habits or food of the young, and the possibility of propagating the species artificially; and we are quite as ignorant concerning the bluefish, red drum, spotted sea trout, sheepshead, red snapper, and all of the numerous other snappers, groupers, grunts, and porgies. It is not at all unreasonable to suppose that a study of these species would show that many of them can be cultivated artificially, and the time will doubtless come, and all too soon, when artificial propagation will have to be resorted to to save some of these fishes from practical extinction. It is the part of wisdom to develop the methods requisite for conserving the fisheries and have them perfected and ready for use before any serious diminution begins.

No study has ever been made of the food of any of these food-fishes or the many others which swarm in Floridian waters. Except in the most general way we know nothing of the interrelations existing among these various species, and the conditions favorable or unfavorable to the well-being of the useful species.

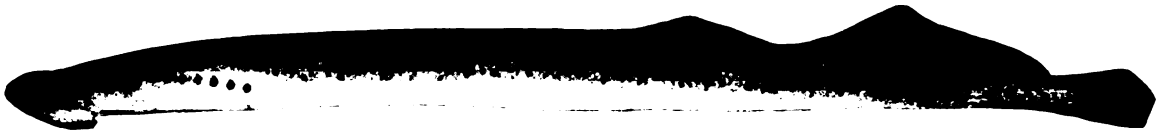
The life-history of the manatee has never been critically studied, and we have doubtless underestimated the importance of its preservation. The same is true of the alligator, crocodile, porpoise, and the several species of turtles found on the Florida coast, all of which are animals of commercial value and of unusual interest to the naturalist.

The discovery and perfecting of methods by which the various commercial sponges of Florida may be cultivated artificially furnish a field for investigation which will prove fascinating in the highest degree and will doubtless yield results of the greatest economic importance.

Each and every one of the lines of investigation indicated is important and worthy of serious attention. Some of them have already been too long neglected. These problems are legitimate fields of investigation.

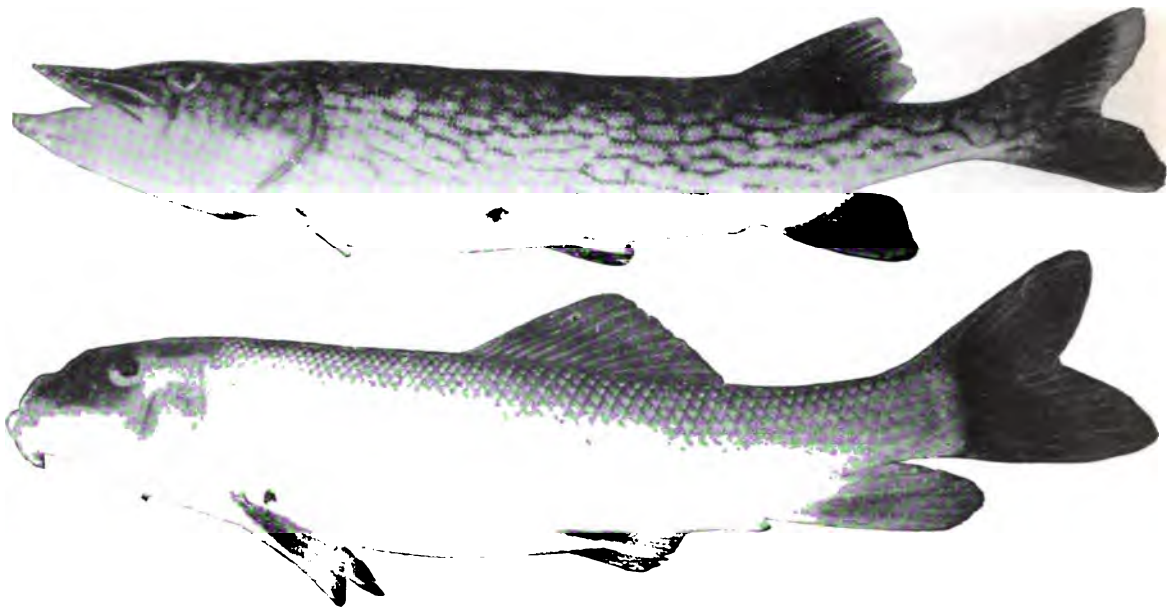
The establishment of a station for biological research at some point on the coast of Florida is abundantly justified upon both scientific and economic grounds, and should receive the early and serious attention of the General Government and the Commonwealth of Florida.

WASHINGTON, D. C.

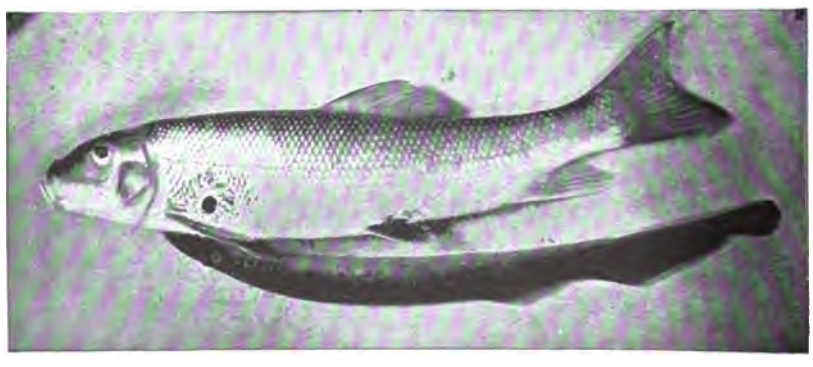


LAKE LAMPREY (*Petromyzon marinus unicolor* De Kay) FROM CAYUGA LAKE, IN WINTER. One-half natural size.

BROOK LAMPREYS (*Lampetra wilderi* Gage). Natural size.
(*a*) male and *b*) female, taken at spawning season and photographed under water with a vertical camera.
(From Plate IV, in the Wilder Quarter Century Book, by S H. Gage )



PICKEREL (*Lucius reticulatus*) AND SUCKER (*Catostomus commersonii*) WITH LAMPREY SCARS.
In both cases the wounds penetrate the abdomen.
(Photographed fresh under water, with a vertical camera.)



LAKE LAMPREY CLINGING TO THE SUCKER UPON WHICH IT WAS CAUGHT.
Note the characteristic Lamprey scars by the pectoral and pelvic fins.

# THE LAMPREYS OF CENTRAL NEW YORK.

By H. A. SURFACE, M. S.,

*Fellow in Vertebrate Zoology, Cornell University.*

The greatest enemy of the fish of Cayuga Lake, New York, is a fish-like animal commonly known as the lake lamprey or lamprey eel (*Petromyzon marinus unicolor*). The name lamprey eel, however, conveys an erroneous idea, as the lamprey is not an eel and resembles the eel only in general external appearance. The name lamper eel is also applied to the mutton-fish or ling (*Zoarces anguillaris*) of the Atlantic coast. It is possibly from the habits of young lampreys that the authors of our old First Readers justified themselves in the statement: "Eels live in mud." Although this animal is altogether too well known to the fishermen of this region, to most persons it is an unfamiliar object.

The generic name, *Petromyzon*, signifies a "rock sucker," because it is sometimes found clinging by its mouth to stones. The specific name *marinus* indicates the fact that its primary or normal home is the ocean; but the variety *unicolor*, of which the type is found in Cayuga, Seneca, and the other "finger lakes" of this region, is a land-locked form which has been able to adapt itself to the inland fresh-water conditions throughout the entire year. This variety, now known as the lake lamprey, has become smaller and more uniform in color (hence the varietal name, *unicolor*) than its probable ancestor, the sea or marine lamprey.

There are about 20 species of lampreys known to science, mostly inhabitants of temperate regions. Two species are found in the Cayuga Lake Basin, of which the lake lamprey is very injurious to our best fishes. The brook lamprey, *Lampetra wilderi* Gage, named in honor of Dr. B. G. Wilder, professor of vertebrate zoology in Cornell University, is much smaller than the former, is not known to be injurious to fishes, and does not occur in the lake. It receives its common name from its constant occurrence in streams. It is not known in the lake, and no reference has been found indicating that it has even been collected in any lake. In the adult state it has never been known (by us, at least) to take any kind of food, and the assumption will doubtless be confirmed that this vertebrate, like some insects, does all of its feeding in the larval stage, and remains in its mature stage or condition only long enough to reproduce its own kind. Its very long larval period (two or three years) and short adult period (a very few months) would appear to give weight to this assumption.

This species of lamprey has never been known here in the adult state except during the spring and summer months, and if it has been collected at any other time in other localities particulars of its occurrence are desired. If there is any reference to

this species attacking fish, or taking other food in the adult state, the information will be very acceptable. Professor Gage has found transforming larvæ the last of October, and full adults on the spawning-beds as early as the 26th of April. Their transformation is doubtless completed before midwinter.

Some very interesting "Notes on the spawning habits of the brook lamprey (*Petromyzon wilderi*)" have been contributed by Bashford Dean and F. B. Sumner (N. Y. Ac. Sci., vol. XVI, December 9, 1897). The authors compare their dates with recorded dates for this region, and conclude that "the spawning season of our local (New York City) lamprey is thus found to be nearly a month earlier than at Cayuga Lake," but to draw accurate conclusions dates in the same year should be compared. In 1897 the brook lamprey was found on beds here on April 30. This makes a difference of 14 days instead of 30 days between New York City and this region. These two species of lampreys are apparently identical in places of spawning, habitat of larvæ, and observed external appearances (i. e., *specific* determinations in the ammocœtes stage are impossible), but the brook lamprey spawns from one to two weeks earlier than the lake lamprey.

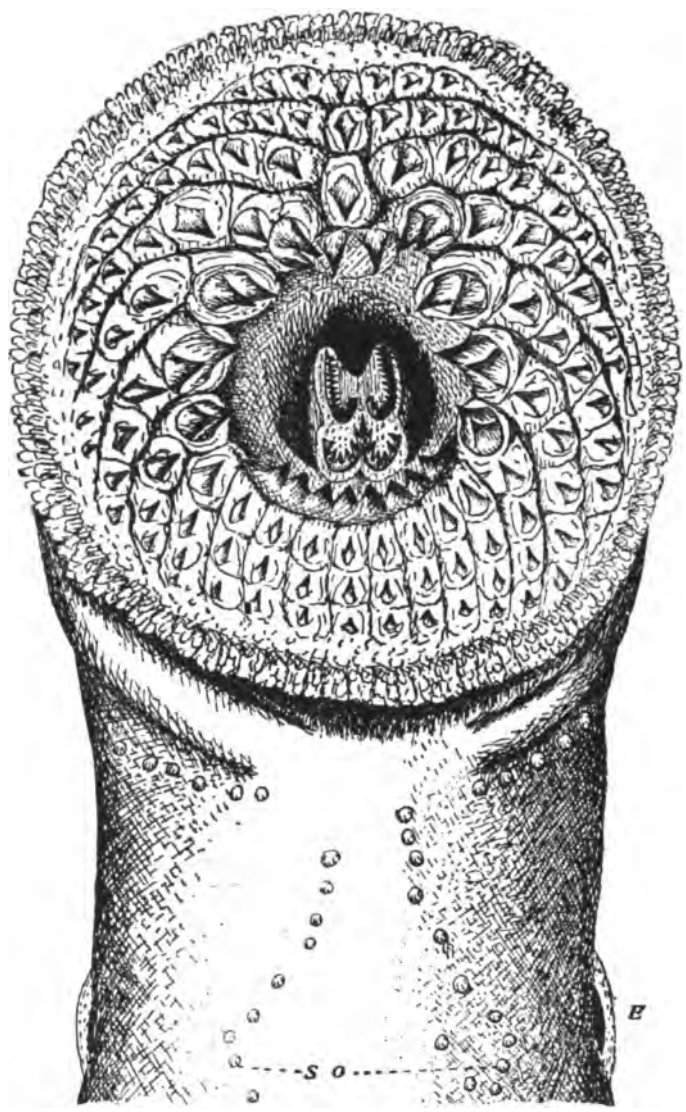
Plate 10 shows one of the lake lampreys attached to a common white sucker (*Catostomus commersonii*), which is also pierced by lamprey marks near both its ventral and pelvic fins, the body-wall being entirely cut through by these blood-suckers, and the abdominal cavity penetrated. This illustration is from a photograph of fresh specimens, under water, taken with a vertical camera, by Prof. S. H. Gage, at Cornell University. Professor Gage and Dr. Wilder have done more work with the lampreys of this region than have any other persons, and it is from Professor Gage's article on "The lake and brook lampreys of New York," in the Wilder Quarter Century Book, 1893, that much information is taken for the present paper. The other illustrations are from photographs of specimens collected in Cayuga Lake or its inlet by persons at Cornell University, and were made for the purpose of showing some special features of the habits of this enemy of our fishes.

The lamprey is similar to the frog and most other amphibians in the fact that from the young stage to the adult it passes through a metamorphosis slightly comparable with the change of a tadpole into a mature frog. Its full life-history, as determined by Professor Gage, is, briefly, as follows:

The adult passes about three years in the lake, living exclusively by sucking the blood from living fishes, most of which are good food-fish. In the springtime, about the middle of April, apparently, they start out independently from the various points of the lake, each one forsaking its prey and swimming vigorously or stealing a ride by attaching to the bottom of some boat moving in the right direction. On they go until the current of the inlet gives them the clue, and they follow it. Frequently, also, ordinary fishes bound on the same errand throng the streams, and then the lampreys, with their inherent desire to be taken care of by the labor of others, fasten to the larger fishes and are carried along up the stream. It not infrequently occurs that from the natural inclination of the stream, or from some of man's obstructions there are rapids or dams to be surmounted. Nothing daunted, the lamprey swims up just as far as possible by a tremendous effort, grasping a stone or other object so that he can not be carried downstream again, rests for a while, and then, by a powerful bending and straightening of the serpentine body, a leap is made in the right direction, and what is gained is saved by again fastening the mouth to a fixed objec-

oes on until the obstacle is surmounted, if it is not too great. Then, without the lamprey pushes on upstream, sometimes 8 or 10 kilometers, until clear water ımerous ripples are found. Just above some ripple the lamprey begins to make a secure place for a new generation.

he male arrives first egins the nest build- removing and plac- ınes with his suctorial . In a few days he is by a female, and to- they labor away un- y have made a basin, some cases a ditch the bed of the ı. Now they fasten elves with their s to stones at the up- ge of this basin, and bodies swing down- ı and sway in the cur-



Mouth of lake lamprey (*Petromyzon marinus unicolor*). Reproduced from a drawing by Mrs. S. H. Gage. E, eye; S O, sense organs.

any hundreds of lam- have been actually ɔd on beds in the inlet ıingle season by ob- s at Cornell Univer- nd in 1891 Professor saw there fully ı,200. ese nests the eggs, being fertilized, sink bottom and adhere to the sand and , being covered by ampreys stirring up ınd with their tails. some days the eggs ıtched and the young eys, very much like angle-worms, burrow ıe sand. At first they ı the sand at the bot- f the nests, but soon their way to the sand along the banks of the stream. Here they remain for ps two years or longer, with their eyes only rudimentary and their mouths lar, feeding on very minute organisms that live in the mud and sand.

ı is said that the adult lampreys die soon after spawning, but this is not fully nined. It is also believed that some may return to the lake. When the young

are sufficiently developed they metamorphose into adults, find their way down the inlet into the lake, and begin the same kind of parasitic bloodsucking life that their parents led. Thus is the cycle of life completed for these creatures.

In structure and zoologic position the lampreys are the lowest vertebrates found in this region, being placed at the very foot of the list of fishes and by most recent authors they are even denied admission into the class of fishes. The class to which they belong is Marsipobranchii, or "pouch gill," because the gills form a series of pouches, seven on each side of the head. They receive their water through as many independent gill-openings.

The adult lamprey swims in the water like a fish, only with more of a wriggling or snake-like movement, but it does not have paired fins placed as in the true fishes. The only organs that it has that functionate as fins are membranous expansions on its back and on the dorsal and ventral sides of its tail.

As will be seen from the figure of the mouth (p. 211), it has no jaws, but its mouth is a large circular disk, thickly studded with large, strong, chitinous spines or teeth, which enable it to more securely grasp its victim. This disk is surrounded by a softer membrane, which readily fits tightly over any surface and makes it possible for the animal to adhere quite firmly to an object by suction when the piston-like tongue in the center is drawn back. Having fastened itself by this wonderful mouth, which is larger around than its head, it rasps away with the saw-like teeth on its tongue, using nearly 150 other teeth, until it has worn through the thick skin or scales of its victim. Then it has nothing to do but to remain attached to the fish and be carried around by it, sucking blood when it is hungry, and occasionally rasping away at its raw flesh, making the hole deeper and deeper until finally the abdominal wall is completely perforated and the body cavity penetrated. Often the intestines or other organs of the fish are attacked and cut to pieces, but more frequently the lamprey fastens itself at another place if its victim has any blood left, or if not it seeks another fish.

The intestines protruding and the blood escaping from the deserted wound, in a great many cases sooner or later cause the death of the fish, which are often seen swimming in the lake in the miserable condition just described. The injured fish does not always die, but in every case it is seriously weakened and reduced in flesh and blood, and in the power of fully reproducing its kind. Among some specimens recently collected for study here was a bullhead or horned-pout (*Ameiurus nebulosus*) that had been so severely attacked by a lamprey that its stomach protruded through the hole in the side. This fish was kept alive in a tank (for the purpose of observing its condition) for three weeks.

Last spring (1897), when using a collecting seine under the permission and direction of the New York Fisheries, Game, and Forest Commission, the writer found by actual experiment that it was easy to distinguish the bullheads that had been attacked by lampreys, even when they were purposely turned over so that the holes were not visible. The injured fish loses entirely its rich golden hue, and, assuming a sickly appearance, grows paler and weaker. It is not at all uncommon to find dead fish along the shores of Cayuga Lake, and upon examination the marks of the lamprey may be seen. Among such fish recently found are the bullhead or catfish (*Ameiurus nebulosus*), suckers (*Catostomus*), carp (*Cyprinus carpio*), lake herring (*Argyrosomus artedi*), and pickerel (*Lucius reticulatus*). Other species of food-fish are also injured. It is a serious enemy of the sturgeon (*Acipenser rubicundus*), one of which was caught in

A DOZEN CATFISH (*Ameiurus nebulosus*) FATALLY ATTACKED BY LAKE LAMPREY (*Petromyzon marinus unicolor*).
Collected and photographed by H. A. Surface.

EIGHT CATFISH (*Ameiurus nebulosus*) FATALLY ATTACKED BY LAKE LAMPREY (*Petromyzon marinus unicolor*).
Collected and photographed by H. A. Surface.

Cayuga Lake with six lampreys on it. A local fisherman claims to have captured a very large sturgeon which had 21 lampreys attached to it.

In addition to the above list other valuable fish which have been attacked are the whitefish, pike, muskellunge, bass, perch, lake trout, wall-eyed pike, redhorse or mullets (*Moxostoma macrolepidotum* and *M. aureolum*), the eel (*Anguilla chrysypa*), drum (*Aplodinotus grunniens*), white bass (*Roccus chrysops*), and others. In fact, of the 74 species of fish found in Cayuga Lake basin, none is known to be free from its attacks except those too small for its attachment and support. Several injured specimens of the bowfin, mudfish or dogfish (*Amia calva*) have been seen; even the heavy-scaled ganoid, the gar pike or billfish (*Lepisosteus osseus*), is sometimes attacked. Fine specimens of lake trout (*Cristivomer namaycush*) with as many as five wounds on one fish have been found. With smaller fishes one attack sometimes proves fatal; often, however, the fish may survive the first attack and fall a victim to the second or even third. Only a fish of considerable size and vitality can survive five or more wounds without intervals for recuperation.

The records kept in field work here show that lampreys are much more injurious, or a much greater percentage of fishes are injured in the early spring (February and March) than at any other time. This season of feasting may be to strengthen them for the long period of fasting and spawning, for it is shown that they not only refuse to feed during the spawning season, but owing to the atrophy of the alimentary canal they are entirely incapacitated for taking food.

Professor Gage has estimated that the lamprey annually does as much in reducing the available food-fish in this lake as all the work of the fishermen combined. He has also shown that of the bullheads captured in the lake 12 out of every 15 have been attacked by the lamprey. From careful observations made within the past year, the writer is prepared to confirm and emphasize both of the above statements.

The attacks on the bullhead or catfish alone are of great importance. It is safe to say that hundreds of barrels (probably about 500,000 pounds) of these are placed annually upon the markets in the State of New York. In most cases they are dressed. No wonder! Who wants to buy or eat fish with great festering sores or ulcers visible? And yet the bullheads are excellent food-fish. That their value is recognized by experts is attested by the fact that last year the State Fish Commission of New York furnished the State Fish Commission of Ohio with 1,200 of them for stocking certain streams in the latter State.

From every economical standpoint it would appear to be advantageous to rid the world entirely of the lampreys. It would certainly be greatly to the advantage of the fisheries of the State of New York if all were destroyed. Naturally, however, the student of biology must mourn the loss of a form so interesting and so instructive. The questions naturally arise: "How can the fish be protected from the lampreys; and is it possible to remove the lampreys from our lakes? Thanks to the service science has rendered by the twenty-five years' study of this subject by Dr. Wilder and Professor Gage, the modus operandi becomes comparatively simple, as shown by the following quotations from the latter's paper.

> It will be seen that it [the lamprey] has one very vulnerable point, viz, leaving the lake and running up the tributaries to spawn. This seems to be the only point at which the lamprey can be attacked, and the hope of exterminating it is rendered still stronger from the fact that in Cayuga and Seneca lakes, so far as explored (during several seasons), the lampreys run up the inlet at the head of the lake only, and do not spawn in the tributaries entering the lake at intervals on each side.

Lampreys must be destroyed before spawning if they are to be exterminated. Nothing would be easier than to do this. A dam with a fishway—the fishway leading into an isolated inclosure—where the lampreys could be easily removed and disposed of, or a weir of some kind, could be constructed at slight expense. If this could be continued for three or four years in all the lakes and in the Oswego River, the race could be extinguished and the lakes wholly freed from their devastations.

In the diagram A represents perpendicular posts set in the stream and fastened, for the purpose of catching floating material that might otherwise tear or injure the weir below. B represents net wings for the capture of creatures running down the stream. C represents the main or chief net placed entirely across the stream to prevent passage either way. At D is the pocket or pen in which the fish coming up the stream will ultimately be found, being guided by the various wings of netting or wire E and F.

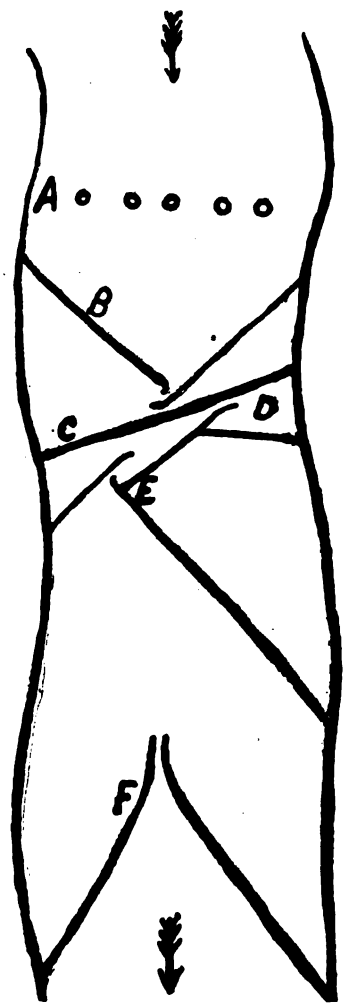



Diagram of weir for catching lampreys as they run up the stream to spawn. (Arrow indicates direction of current.)

It can be seen that if a weir for this purpose were established in the inlet of Cayuga Lake, not only would it do a great deal of good in removing the lampreys, but what is much more, it would give some vastly important absolute facts to the State authorities upon which they may be able to definitely base plans and calculations for more extensive operations at other lakes for another year. Also, one can scarcely estimate what a valuable amount of scientific information would be gained concerning our anadromous fishes as they run up the stream to spawn and return to the lake again. Important investigations could here very easily be made, and many valuable facts could be gained by such investigations properly conducted. Until trained investigators give our legislators many facts not now known, laws that will prove effectual in the protection and maintenance of fish or game can not be enacted.

For example, the laws for the protection of fish are in most cases based upon their spawning habits, and this is of course right; but no one can give or find correct answers to the following questions for even one-fourth of the number of kinds of fish found here:

Just when do they commence to spawn, and when is the spawning completed? How long before spawning do they run up the streams, and how long after do they return to the lake or sea? Just what species find it necessary to run up the streams for spawning, and what remain in the lake? What is their food, and what their enemies and diseases at this most important time in the life of the fish? What is their modification in structure, or condition of all organs, and their food before, after, and during spawning? In what numbers do they run up the streams, and what proportions are males or females? What kind of nest do they build, and do both sexes take part in its construction? Which sex cares for the eggs, and which for the young, and how? And, how long do the young need or receive parental protection?

All of these questions and many others that could be asked are of great importance, but can never be answered except through some such careful investigations as

can be made in connection with the proposed weir, the diagram of which is given. The plans have been very carefully made, and meet the hearty approval of the State fish, game, and forest commissioners. It has been placed in the inlet above the limit of navigation and below the lowest place where the lampreys spawn. Two watchmen are employed to alternate in watching this weir constantly, day and night, during the "running" season, and, empowered as deputy sheriffs, the watchmen will be able to arrest any trespassers who might otherwise seriously interfere with the success of the experiment.

A specialist from Cornell University visits the weir every morning and evening at regular intervals, and with a shallow dip net removes the lampreys and helps over the good fish and lets them go on their way. A strict count and record is made of the kinds seen and of the number of each, their condition, development, habits, and such other points as are of economic or scientific interest and help to give correct answers to the questions above asked. By conscientiously performing this work it is also possible to determine what percentage of each species migrates in the daytime and what at night.

President B. H. Davis, of the Fisheries, Game, and Forest Commission, conferred with Senator Stewart on this subject, and the latter, at the request of the former and several other interested persons, introduced a bill, as an item in the general supply bill, for $500 for this work. Last year our legislators passed a bill appropriating $1,500 for the removal of the billfish or gar pike from Black and Chautauqua lakes; and here in Cayuga Lake, the largest of the interior lakes of the State, the lamprey is fully one hundred times as injurious to the fishing industry as is the billfish, and the amount asked for and granted is only one-third of last year's specific appropriation. The appropriation was made without dissent, and the New York State fish-culturist, Hon. A. N. Cheney, now has general charge of the affair. The special investigations and experiments are to be made by the writer and the results published by the Fisheries, Game, and Forest Commission of the State of New York.

Many eminent scientists and other persons have written, expressing interest in this subject and the possible results of this experiment.

ITHACA, NEW YORK.

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ADDENDUM.

APRIL 25, 1898.

At this date the weir for removing lampreys from the inlet of Cayuga Lake is constructed and in successful operation. Although it is too early in the year for any results with the lake lamprey (*Petromyzon marinus unicolor*), some interesting facts have already been obtained concerning the brook lamprey (*Lampetra wilderi*). On April 9, the first day the weir was in working order, one adult male of this species was found in it, and on the 11th two others. On the 16th it contained several adult males and females; on the 20th one male and two females, and on the 22d two more females. These were striving to swim up the stream, presumably to regain the places from which they had doubtless been washed during the past year as larvæ in the sand, since their spawning-beds are all above this. In a tank at Cornell University several specimens taken from the sand six weeks ago have not only transformed into adults, but the reproductive organs of both sexes have matured, and one female was spawning when she died. This was without having taken food, and we are still further led to believe that adults of the brook lamprey are not parasitic, and, indeed, take no food at all.

H. A. SURFACE.

# THE PROTECTION OF THE LOBSTER FISHERY.

By FRANCIS H. HERRICK, Ph. D.,
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In the lobster fisheries we have an example of an industry which has increased rapidly in value in a very few years. In 1869 the Canadian fishery was valued at $15,275; in 1891, at $2,250,000.[1] In twenty-two years its value increased nearly 150 fold. The value of the products of this industry in the United States was nearly half a million dollars in 1880 ($488,432), and in 1892 over a million dollars ($1,062,392).[2] In 1896 there were 14,285,157 cans of lobster packed in Canada, having a value of $2,400,000. The average price per pound in 1883 was 9½ cents; in 1893 it had risen to 14.10 cents, and at the present time it is 18.72 cents.[3]

The decline of the lobster fishery is a well-worn theme. The facts pointing to its gradual but certain decay are too evident to be mistaken, such as the interminable legislation on the subject of protection, the increase in the number of traps, the decrease in the size of the lobsters themselves, and their increase in market value. Twenty-five years ago the lobster was common; now it is generally a luxury.

The cause of the depletion of the fishery is plain. The supply has been unequal to the demand. More lobsters have been annually destroyed than have been annually raised. No number of animals, however large, can stand such a drain. For twenty-five years the law in Canada has been called to the aid of the fishery. It has taken a vacillating course in both the Provinces and the United States, revoking one year what was enacted the year before, adopting this and that suggestion, and jumping from one expedient to another. Regard to personal interests, imperfect knowledge of the habits and needs of the animal itself, and perverted logic have characterized much of the legislation which governments have enacted for the preservation of animal life. There are, indeed, praiseworthy exceptions, and legislation, though it has often failed, may have been animated by the right spirit.

The problem of perpetuating an animal like the lobster, or rather of maintaining the supply, for it is not in the power of man to exterminate this species, is certainly a difficult one. In order to discuss this or any similar question profitably and intelligently, it is necessary to set aside pride and prejudice of every kind, whether personal, sectional, or national, and consider in a judicial spirit the conditions in which this

[1] Report on the lobster industry of Canada, 1892. Supplement to 25th Annual Report of the Department of Marine and Fisheries, 1893.

[2] The American Lobster. Bulletin of the U. S. Fish Commission, 1895, p. 12.

[3] Discoloration in canned lobsters, by Andrew Macphail. Supplement to 29th Annual Report of the Department of Marine and Fisheries, 1897.

problem is involved. We must know the state of the fishery and the principal facts pertaining to the life and habits of this animal.[1]

Until within a few years the life-history of the lobster was very imperfectly known, and this ignorance has nowhere been more clearly reflected than in the attempts to cure existing evils by legislation. Knowing the general facts of the case, we must interpret them in accordance with the principles of science and common sense. The principal facts are these[2]:

(1) The fishery is declining, and this decline is due to the persistence with which it has been conducted during the last 25 years. There is no evidence that the animal is being driven to the wall by any new or unusual disturbance of the forces of nature.

(2) The lobster is migratory only to the extent of moving to and from the shore, and is, therefore, practically a sedentary animal. Its movements are governed chiefly by the abundance of food and the temperature of the water.

(3) The female may be impregnated or provided with a supply of sperm for future use by the male at any time, and the sperm, which is deposited in an external pouch or sperm receptacle, has remarkable vitality. Copulation occurs commonly in spring, and the eggs are fertilized outside the body.

(4) Female lobsters become sexually mature when from 8 to 12 inches long. The majority of all lobsters 10½ inches long are mature. It is rare to find a female less than 8 inches long which has spawned, or one over 12 inches in length which has never borne eggs.

(5) The spawning interval is a biennial one, two years elapsing between each period of egg-laying.

(6) The spawning period for the majority of lobsters is July and August. A few lay eggs at other seasons of the year—in the fall, winter, and probably in the spring.

(7) The period of spawning lasts about six weeks, and fluctuates slightly from year to year. The individual variation in the time of extrusion of ova is explained by the long period during which the eggs attain the limits of growth. Anything which affects the vital condition of the female during this period of two years may affect the time of spawning.

(8) The spawning period in the middle and eastern districts of Maine is two weeks later than in Vineyard Sound, Massachusetts. In 1893 71 per cent of eggs examined from the coast of Maine were extruded in the first half of August.

(9) The number of eggs laid varies with the size of the animal. The law of production may be arithmetically expressed as follows: *The number of eggs produced at each reproductive period varies in a geometrical series, while the length of lobsters producing these eggs varies in an arithmetical series.* According to this law an 8-inch lobster produces 5,000 eggs, a lobster 10 inches long 10,000, a 12-inch lobster 20,000. This high rate of production is not maintained beyond the length of 14 to 16 inches. The largest number of eggs recorded for a female is 97,440. A lobster 10½ inches long produces, on the average, nearly 13,000 eggs.

(10) The period of incubation of summer eggs at Woods Hole is about ten months, July 15–August 15 to May 15–June 15. The hatching of a single brood lasts about a week, owing to the slightly unequal rate of development of individual eggs.

[1] In discussing this subject I have not attempted to discriminate between conditions which may exist in the United States and the Maritime Provinces. The questions to be considered have primarily a general significance.

[2] For further details see The American Lobster, Bull. U. S. F. C. 1895, pp. 1–252.

(11) The hatching period varies also with the time of egg-laying, lobsters having rarely been known to hatch in November and February.

(12) Taking all things into consideration the sexes appear about equally divided, though the relative numbers caught in certain places at certain times of the year may be remarkably variable.

(13) Molting commonly occurs from June to September, but there is no month of the year in which soft lobsters may not be caught.

(14) The male probably molts oftener than the female.

(15) In the adult female the molting like the spawning period is a biennial one, but the two periods are one year apart. As a rule, the female lays her eggs in July, carries them until the following summer, when they hatch; then she molts. It is possible that a second molt may occur in the fall, winter, or spring, but it is not probable, and molting just before the production of new eggs is a rare occurrence.

(16) The egg-bearing female, with eggs removed, weighs less than the female of the same length without eggs.

(17) The new shell becomes thoroughly hard in the course of from six to eight weeks, the length of time requisite for this varying with the food and other conditions of the animal.

(18) The young, after hatching, cut loose from their mother, rise to the surface of the ocean, and lead a free life as pelagic larvæ. The first larva is about one-third of an inch long (7.84 mm.). The swimming period lasts from six to eight weeks, or until the lobster has molted five or at most six times, and is three-fifths of an inch long, when it sinks to the bottom. It now travels toward the shore, and, if fortunate, establishes itself in the rock piles of inlets of harbors, where it remains until driven out by ice in the fall or early winter. The smallest, now from 1 to 3 inches long, go down among the loose stones which are often exposed at low tides. At a later period, when 3 to 4 inches long, they come out of their retreats and explore the bottom, occasionally hiding or burrowing under stones. Young lobsters have also been found in eelgrass and on sandy bottoms in shallow water.

(19) The food of the larva consists of minute pelagic organisms. The food of the older and adult stages is largely of animal origin with but slight addition of vegetable material, consisting chiefly of fish and invertebrates of various kinds. The large and strong also prey upon the small and weak.

(20) The increase in length at each molt is about 15.3 per cent. During the first year the lobster molts from 14 to 17 times. At 10½ inches the lobster has molted 25 to 26 times and is about five years old.

After reviewing the most important facts concerning the life of this animal we are ready to discuss the methods which have been tried to prevent its destruction, such as: (1) The protection of immature lobsters by establishing a legal-size limit, or by regulating the construction of traps, or by making close seasons—periods of the year when fishing is illegal; (2) protecting the "berried lobster" or females with external eggs; (3) regulating the canning industry; and (4) attempting to increase the supply of lobsters by artificial propagation. It must be admitted that up to the present time all these measures have proved very disappointing.

The desire to protect the immature lobster and allow it to breed at least once in its life is certainly commendable. It is largely because of the failure of efforts to attain this result that the fishery is now in decline. One reason for this is that there are no obvious means of determining whether a live lobster has in every case produced

eggs or not, and another is that the lobster often matures at a much later period than has been generally supposed. The legal size limit in Canadian waters fluctuated from 9 to 9½ inches between 1874 and 1892. In 1895 the legislature amended the law, making it illegal to take lobsters less than 10½ inches long. In 1895 the legal limit in Maine, Massachusetts, New Hampshire, and New York was 10½ inches; in Rhode Island 10, and in Connecticut 6 inches. The legislature of Massachusetts was ready to reduce the 10½ limit the next year, but its act was vetoed by Governor Wolcott.

Some lobsters are known to produce eggs when 8 inches long; therefore, it is said, a 10½-inch limit is too great. This can not be allowed. While a few female lobsters produce eggs when 8 inches long, the majority at this size do not. The same is probably true of lobsters 9 and 9½ inches long. Some lobsters do not spawn until after reaching the length of 12 inches, and the limit of 10½ inches is none too great. Thus we see how such attempts to protect the lobster have failed through the legalized killing of immature individuals.

The legislation on the subject of close seasons forms a curious piece of reading. Ignorance of the fact that the lobster carries her eggs for the period of ten months has been an element of confusion here. In Canada, almost every combination of the calendar has been tried. Close seasons for canning establishments, for fishermen, and for different sections of the coast have been tried in vain, but no combination has brought good or lasting results.

The object of a close season is to let the animal breed in peace, but there is a peculiar difficulty in the case of the lobster which makes it impossible to confer any protection upon it worth mentioning by a short close season. The difficulty lies in the fact that the animal does not drop its eggs in the sea or deposit them on some foreign substance, as the older naturalists believed, but carries them on its body. Consequently, in order to protect the eggs you have to protect the egg lobster. This has been attempted in the United States and in Canada by making it illegal to sell the "berried lobster." But the object is defeated by the ease with which this law can be evaded. It is only necessary to scrape the eggs from the body. Again, to obviate this, attempts have been made to allow the capture of "berried lobsters" and to buy up the eggs from the canneries and hatch them by artificial means. On this point I shall speak later.

The period of egg-laying on the coast of the United States extends, as we have seen, over the months of July and August. If fishing in these months is closed the spawners are protected.[1] This can be done, and would result in some good, but at either end the spawning females would be subjected to fire. First, there being no way to detect females which are ready to spawn, these would be killed in great numbers up to the beginning of the period; then, after the close in September, if egg lobsters were captured and the eggs removed and destroyed, the good which has been done would be partially neutralized.

Protection to the immature lobster by regulating the construction of traps, making the distance between the lower slats sufficiently great to let out all the lobsters except those of the legal size—10½ inches—is a measure which, if generally carried out, could not fail to be beneficial.

The canning industry is undoubtedly responsible for a large share in the depletion of this fishery. It is operated in the spring, and for years has destroyed large

[1] This period is well covered by the close period in Massachusetts, which extends from June 20 to September 20.

numbers of immature lobsters and of mature females nearly ready to spawn. The canneries have been allowed to use smaller lobsters than those which are sent to market, and we are told that if further restricted they could not exist. Whether this is true or not I do not know, but it is surely folly to protect an animal in one direction and allow it to be destroyed in another.

We have now to speak of the artificial propagation of the lobster as a means of maintaining or increasing the supply. In 1893 I tried to point out some of the fundamental errors which rendered the methods of artificial propagation abortive. The objections which were then made have never been answered or removed.[1] The difficulty is that a false logic has dominated the whole subject, not only of the propagation of the lobster, but of many of the true fishes, both in this country and in Europe. This is shown by the fact that the number of eggs hatched has been taken as a direct test of the efficiency of the method. The question of prime importance, which overtops all others, *what is the ratio between the number of eggs hatched and the number of young reared*, has been strangely left in the background or lost sight of. The following sentence, which I quote from a report on the lobster industry in Canada, illustrates the tendency to which I refer:

> The fecundity of the lobster is wonderful. Every female reaching the age of maturity emits from 12,000 to 20,000 eggs every season.[2]

What is here implied is that because the lobster produces a large number of eggs there must be a large number of lobsters raised from those eggs. This is a fundamental mistake. In the animal kingdom the production of a large number of eggs points, not to a great number of survivals and consequent abundance of the species, but to the great destruction of young, which makes a large number of eggs a necessity in order to maintain the species even at an equilibrium. A blue crab (*Callinectes hastatus*) of medium or large size produces 4,500,000 eggs, or 157 times the number of eggs laid by a lobster 13 inches long. Does this imply that the ratio of survival in the crab is 157 times greater than that of the lobster or that the crab is 157 times more abundant than the lobster at any point on the coast? Not at all. It rather implies that the crab lays a smaller egg, has a longer larval period, and is subject to far greater destruction by the elements of nature. In order to preserve its equilibrium, this expedient of producing a vastly greater number of eggs than can possibly survive has been tried in nature and has met with success. In the tapeworm we have an animal with individualized segments, capable of producing millions or even hundreds of millions of eggs, and yet it is comparatively rare, since the chances for survival of each of those millions of eggs is very slight, for in order to live the embryo or larva must find its way by chance to the body of two particular and distinct vertebrates.

In the course of the struggle for existence among animals and their evolution this chance of survival has been increased in other ways than by the multiplication of ova, as by asexual reproduction seen in budding, or by acquisition of special habits or instincts. In the vegetable world we are even more familiar with the great destruction of seed; thus in the common elm, how many of the hundreds of thousands of seeds which annually fall to the ground from a single tree are ever raised to maturity?

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[1] The habits and development of the lobster, and their bearing upon its artificial propagation. Bull. U. S. Fish Com. 1893, pp. 75–86.

[2] This statement is erroneous in that eggs are laid only every other year.

Is it possible to determine the number of survivals in an animal like the lobster! We can not fix the number positively, but we can fix a maximum limit beyond which we may be sure, reasoning from known facts, the number of survivals can not pass. By *survivals* I mean the number of eggs which develop and grow up to maturity, for death, at whatever point occurring at this period, means evil to the species in exactly the same degree. In order to maintain the species at an equilibrium it is only necessary that each female produce two adults in the course of her life, whether it be long or short. Then there will be neither increase nor diminution, but the species will hold its own. If more than two adults are raised from the eggs of each female in a given period, then the species must increase; if less, it must diminish. Under present conditions it is generally agreed that the lobster is declining, which means that each adult female produces less than two sexually mature individuals to take the place of their parents.

Spawning lobsters may produce as few as 3,000 eggs and as many as 90,000 or 100,000, the number of eggs laid increasing very rapidly in proportion to the increase in size, according to the law given above. While a 10-inch lobster produces on the average 10,000 eggs, a 12-inch lobster bears twice as many, and a 14-inch lobster nearly four times as many, or 40,000. Although sexually mature lobsters can produce eggs only once in two years, many live to hatch several broods and give rise to hundreds of thousands of young. Remembering that females become mature when from 8 to 12 inches long, to be on the safe side we may assume that on the average they mature at the length of 10 inches. A 10-inch lobster produces on the average about 10,000 eggs. Considering all the facts, it is erring on the safe side to assume that the average number of eggs produced by all lobsters which have spawned is 10,000. It is probably much greater than this. It can not certainly be less. Since it is necessary that only two of this number should survive to maintain the species at an equilibrium, we can get some idea of the amount of destruction which is wrought under existing circumstances. A survival of 2 in 10,000 or 1 in 5,000 is probably even greater than actually occurs. The remainder of this large number must be destroyed in one of two ways, by nature and by man, who assists nature in this work after the young are able to be caught in his traps. It can make no difference in the result what the agent of this destruction is, whether it is the ocean current, the storm lashing the rock-bound coast, the codfish, or man, except in so far as the evil wrought by man may be under control. If we award to man one-half of the blame, this would imply that instead of a saving of 2 in 10,000, under nature there might be a survival of 4. But such a survival would lead to a greater increase in the species than could probably ever occur.

What, then, is the ratio of the number of eggs laid to the number of young reared? Allowing that man does one-half of the work of destruction—which he certainly does not—and allowing an average total production of 10,000 eggs to each female that has spawned at all—undoubtedly too small a number—the species would be maintained under nature by a survival of 2 in every 10,000, or 1 in 5,000, if man did not interfere. A survival of 4 in every 10,000, or 2 in 5,000, would keep up the present stock with the added drain which man puts upon it. Considering that the fishery is declining, it can be maintained with a considerable degree of confidence that a survival of 1 in 5,000 is a very liberal allowance.

These considerations have a direct bearing upon the efficiency of the present methods of artificial propagation, which consist of stripping off the eggs from the

berried female, hatching them, and liberating the young larvæ into the sea. Nature does not confer any special favors upon the young lobster thus brought into the world. It is not a case of making two blades of grass grow where but one would have grown before. A delicate, helpless organism, one-fifth of an inch long, it must contend alone with the forces of the world into which it is cast, the ocean, on the surface of which it is destroyed by millions through the indiscriminate forces of nature—the tempest, the tide, the ocean current, and wave-beaten shore—and we must add to this the destruction wrought by surface-feeding animals.

With the liberal allowance of the survival of 2 individuals out of every 10,000 hatched, we would have to hatch 1,000,000 eggs to produce 200 adults, 100,000,000 to get 20,000, and 1,000,000,000 to obtain 200,000 adult animals. To raise 1,000,000 lobsters would involve the hatching of 5,000,000,000 eggs. Since hundreds of thousands of adult lobsters are captured every month during the best of the season, it is evident that the annual supply can not be appreciably affected by this method unless conducted upon an altogether impracticable scale.

The greatest number of lobsters artificially hatched and liberated in a single year in Newfoundland, Canada, and the United States, according to the official reports for 1894, was 702,288,000.[1] This number of young at the rate of survival of 1 in 5,000 would yield 140,457 adults, while in a single year (1892) 68,000,000 lobsters have been captured in Canada alone. In order to put an equivalent number of lobsters back to make good this loss, not half or three quarters of a billion should have been hatched, but 340,000,000,000, or something less than 500 times as many as were actually liberated. In this case man has attempted by working on a small scale to stem the tide of destruction. which nature working on such a vastly greater scale has been unable to do.

The conclusion which we reach is that too much has been expected from the present method of the artificial propagation of the lobster, and that it is totally inadequate to accomplish the task of restocking the depleted waters.

It may properly be asked of one who makes criticisms to suggest remedies, although he is not wholly responsible for the performance of this task. The following suggestions without further discussion seem to me to have a logical basis:

(1) That the coasts of those States in which the lobster fishery is of sufficient importance be divided, after careful consideration, into a number of well-marked areas, and that fishing for this animal be closed in each alternate section for a period of five years; at the end of this time the open areas to be closed, and so on alternately.

(2) That the legal limit be fixed at 10½ inches for all purposes and under all conditions.

(3) That all traps be registered and marked, and that their construction be regulated by law so that the space between the two lower slats be sufficient to allow free passage to all lobsters under 10½ inches in length.

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[1] The number of young lobsters hatched and liberated on the Atlantic coast since 1893 is given by the official reports as follows:

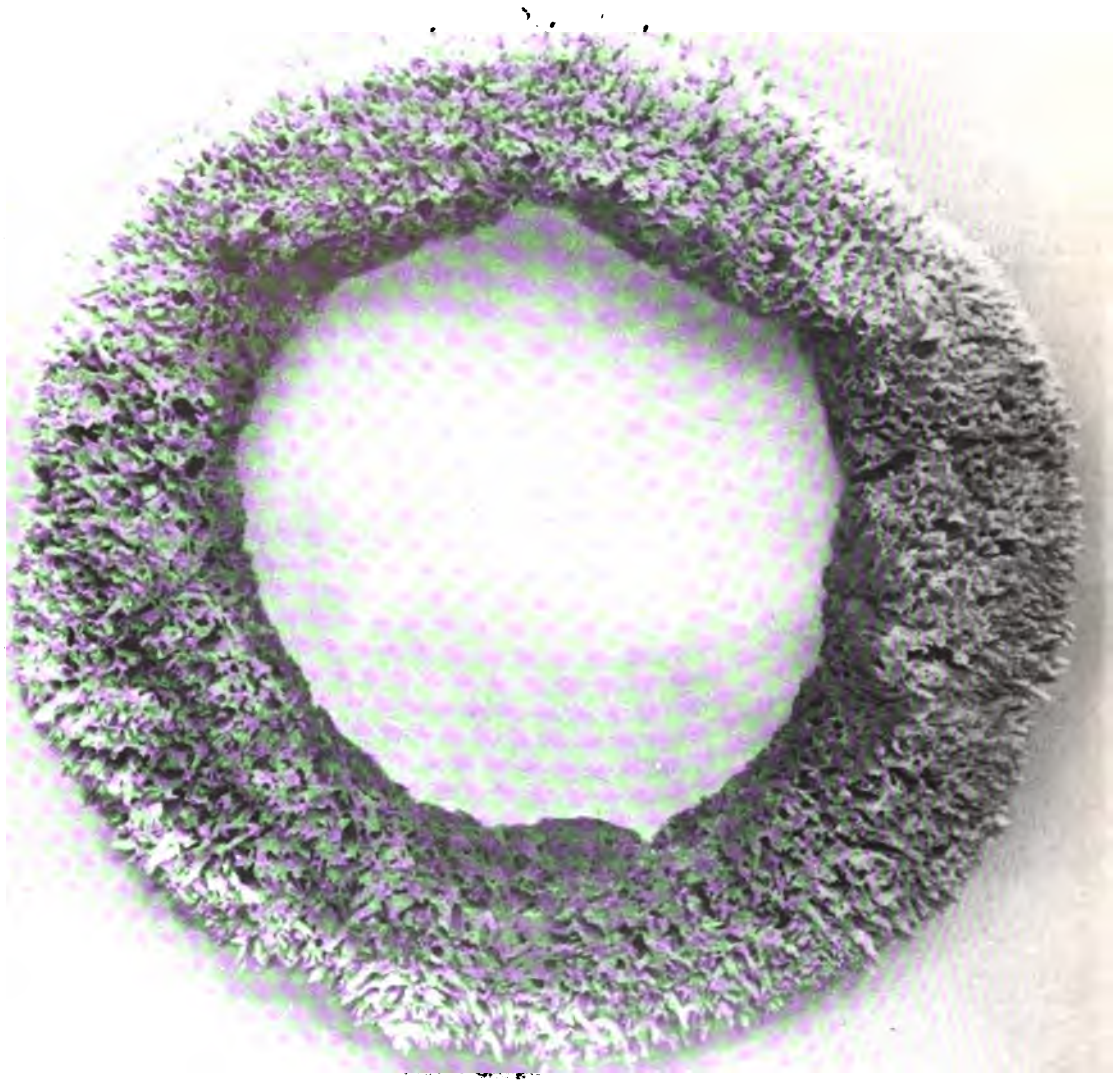
| Fiscal year. | United States. | Canada. | Newfoundland. |
|---|---|---|---|
| 1893 | 8,818,000 | 153,600,000 | 517,353,000 |
| 1894 | 78,398,000 | 160,000,000 | 463,890,000 |
| 1895 | 72,253,000 | 168,200,000 | 174,840,000 |
| 1896 | 97,079,000 | 100,000,000 | ..... |
| 1897 | 115,606,000 | ..... | ..... |

(4) That the capture of berried lobsters be prohibited at all times. Though a law of this kind is sure to be more or less evaded, it is not expedient to encourage the destruction of eggs under any circumstances.

A series of experiments should be tried in raising the young in spacious inclosures, where crowding in vertical and horizontal limits could be avoided, and where a natural supply of food could be provided, the object being to determine whether it is practicable to raise the young up to the fifth and sixth stages, when they go to the bottom and are able to protect themselves. If then set free, the chances of survival would be many hundred times greater than in the first stages. If we could save 100 instead of 2 out of every 10,000 hatched, every 1,000,000 would give us 10,000 adults, and every 1,000,000,000 would yield 10,000,000 lobsters capable of reproduction. In such attempts to rear the lobster there are serious obstacles to be overcome in isolating the young, and giving them an abundant supply of pure water which shall at the same time yield the proper food, but we can not enter into the discussion of these subjects in this paper.

The close period referred to above should begin about June 20, and extend five years and two months from that time to August 20. To illustrate it, we will say that it begins June 20, 1900, and extends to August 20, 1905. During this period 6 sets of lobsters would spawn; 2 of these sets would spawn three times, 2 sets would spawn twice, and 2 once. Thus the set spawning in 1900 would lay eggs again in 1902, and again in 1904, and so on. Furthermore, the survivors of the broods of 1900 and 1901 would be mature, or nearly so, at the end of this period in 1905.

CLEVELAND, OHIO.



SHEEPSWOOL SPONGE.

From Matecumbe Key, 1895. Diameter of wreath, 30 inches; width of sponge proper, 7 inches; weight (dry), 1 pound 7 ounces.

# THE FLORIDA COMMERCIAL SPONGES.

By HUGH M. SMITH, M. D.,

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The sponge fishery of the United States presents the interesting antithesis of an industry restricted to a single State and a product perhaps more generally employed and having a wider range of usefulness than any other article yielded by the American fisheries. There is scarcely a civilized habitation in the country in which the sponge is not in almost daily use. Besides its very general employment for toilet purposes, it is utilized in many other ways—in the arts, trades, and professions, and in domestic life—the mention of which would prove tedious.

In this paper it is not expected that much new or original information concerning sponges will be presented. All that is contemplated is to direct attention to certain aspects of the sponge industry, with a view to place it on a sounder basis. The special topics considered are the distribution, form, and peculiarities of the different species; their present and past abundance; the extent and causes of the decrease in the supply, as evidenced by a diminished annual catch; the protection of sponge-grounds; the cultivation of sponges on grounds now barren; and the increase of the productiveness of the industry by the introduction of some of the best grades of European sponges. In order to make the discussion of these subjects clearer to the sponge interests, it is desirable to briefly notice the zoological status of sponges and their methods of reproduction and growth. Reference is also made to the sponge legislation of Florida. Illustrations of the leading grades of marketable sponges are presented; these are based on specimens collected in Florida by the writer.

## THE NATURE AND STRUCTURE OF SPONGES.

Although for many years the status of sponges—whether animal or vegetable—was in dispute, the time has long since passed when the right of the sponges to be placed in the animal kingdom was established. Even the propriety of assigning the sponges to a position higher than the lowest animals—the protozoa—is now conceded, and they are put either in a subkingdom of their own (Porifera) or in a subkingdom (Cœlenterata) with the corals, gorgonians, sea-feathers, jelly-fishes, etc.

The sponge in a natural state is a very different-looking object from what we see in commerce. The entire surface is covered with a thin, slimy skin, usually of a dark color, perforated to correspond with the apertures of the canals. The sponge of commerce is in reality only the home or the skeleton of a sponge. The composition of this skeleton varies in the different kinds of sponges, but in the commercial grades it consists of interwoven horny fibers, among and supporting which are spiculæ of

siliceous matter in greater or less numbers and having a variety of forms. The fibers consist of a network of fibrils whose softness and elasticity determine the commercial quality of a given sponge. The horny framework is perforated externally by very many minute pores and by a less number of larger openings. These are parts of an interesting double-canal system, an external and an internal, or a centripetal and a centrifugal.

At the smaller openings on the sponge surface, channels begin which lead into dilated spaces (sacs or ampullæ); in these, in turn, channels arise which eventually terminate in the large openings (craters or oscula). Through these channels or canals definite currents are constantly maintained which are essential to the existence of the sponge. The currents enter through the small apertures and emerge through the large ones.

The active part of the sponge—that is, the part concerned in nutrition and growth—is a soft, fleshy mass partly filling the meshes and lining the canals. It consists largely of cells having different functions—some concerned in the formation of the framework, some in digestion, some in reproduction. Lining the dilated spaces into which the afferent canals lead are cells surmounted by whip-like processes (cilia); the motion of these processes produces and maintains the water currents, which carry the minute food products to the digestive cells in the same cavities.

Sponges multiply by the union of sexual products, certain cells of the fleshy pulp assuming the character of ova and others that of spermatozoa. Fertilization takes place within the sponge. The fertilized eggs, which should now be called larvæ, pass out with the currents of water; and, being provided with cilia, swim actively for a while, like larval oysters. In a comparatively short time, probably in 24 to 48 hours, they settle and become attached to some suitable surface, where they in time develop into mature sponges.

## THE FLORIDA COMMERCIAL SPONGES.

The merchantable sponges of the waters of Florida fall under five heads—the sheepswool or "wool" sponge, the velvet sponge, the grass sponges (two species), the yellow sponge, and the glove sponge. Numerous varieties have been described by naturalists and many grades are recognized by dealers, but all are included in the foregoing designations.

The principal center of the industry is Key West, where more than seven-eighths of the business is carried on. Other places at which sponges are landed are Apalachicola, St. Marks, and Tarpon Springs. About 100 registered vessels and 200 unregistered vessels and boats are employed in the fishery, which, with their outfit, are worth about $260,000, and are manned by upward of 1,400 fishermen.

Sponges are by far the most important of the fishery products of Florida, representing about one-third of the annual value of the fishing industry.

In the calendar year 1895 the Florida sponge fishery yielded 306,070 pounds of sponges, of which the first value was $386,871. In 1896 the catch, as represented by the purchases of the wholesale buyers, who handled practically the entire output, was 234,111 pounds, having a value of $273,012. In 1897 the product was 331,546 pounds, valued at $284,640.

The quantity and value of the yield of the different grades in each of the three years named are shown in the following table. This information is compiled from the

cords of the sponge-buyers. The figures represent the actual purchases of the cal dealers, with the exception of the business of one buyer, the details of which ave been estimated.

| Kinds. | 1895. | | 1896. | | 1897. | |
|---|---|---|---|---|---|---|
| | Pounds. | Value. | Pounds. | Value. | Pounds. | Value. |
| Sheepswool | 231,272 | $363,107 | 149,724 | $248,196 | 157,476 | $240,599 |
| Yellow | 29,509 | 11,798 | 23,655 | 9,318 | 32,362 | 13,082 |
| Grass | 21,387 | 5,464 | 44,617 | 11,508 | 128,622 | 29,188 |
| Glove | 14,857 | 2,882 | 15,365 | 2,263 | 9,292 | 1,301 |
| Others* | 9,095 | 3,620 | 2,950 | 1,727 | 3,794 | 1,870 |
| Total | 306,120 | 386,871 | 234,111 | 273,012 | 331,546 | 284,640 |

*Includes, besides velvet sponges, "wire" sponges, "hardhead" sponges, and other miscellaneous grades having little value.

## THE SHEEPSWOOL SPONGE.

The sheepswool is the best sponge found on the shores of the western Atlantic, nd for most purposes has no superior anywhere. While the texture is coarser than hat of the best Mediterranean sponges, this sponge is more durable—a quality of eading importance for most purposes. Belonging to the same species as the native heepswool are the well-known eastern horse sponge, Venetian bath sponge, and Iherbis sponge.

The sheepswool sponge is taken on all the important sponging-grounds on the Florida coast. Its distribution may be said to be from Apalachicola on the west coast o Cape Florida on the east coast, although between Charlotte Harbor and Key West ut few known grounds exist. The most productive are in the vicinity of Anclote Keys nd Rock Island, and from these regions the best quality of sheepswool sponges comes. Between Key West and Cape Florida valuable grounds also exist, those in the vicinity f Matecumbe Key, Knight Key, Bahia Honda, and Biscayne Bay being especially mportant. This species usually grows on the bare coralline rock which underlies a arge part of Florida and is exposed over large areas of the contiguous bottom. On andy or muddy bottom it is rarely found. It is at present taken in water from 10 to 0 feet deep, but the largest quantities are obtained in depths of 20 to 35 feet. In the arly days of the fishery, before the depletion of the grounds had begun, the principal art of the catch was from a depth of less than 12 feet.

With the methods in use in Florida sponges can not be profitably gathered in ater more than 50 feet deep, and a question of considerable interest and importance s whether sponges grow in noteworthy quantities at a greater depth. Most spongers hink that there are important grounds now beyond their reach, but others think that 0 or 60 feet is the maximum depth at which sponges grow. It is claimed by a few ersons that beyond this depth the bottom is not adapted to the growth of sponges, he coralline rock being absent and sand predominating. Definite information on this oint is, however, lacking, and a careful survey would be required to settle the matter. The probabilities are that in certain localities there are productive grounds beyond he present limits of operation, as there is nothing in the nature of sponges to prevent heir inhabiting deeper water, and it seems improbable that the rocky bottoms should ease to exist beyond 50 feet.

Should future inquiry show the presence of sponge-grounds in water from 50 to 0 feet deep, the discovery of a method of utilizing them would be the first considera-

tion and would prove a great boon to the sponge fishery. Not the least important outcome of such a discovery would be the opportunity afforded the shallower grounds to recuperate by the diversion of the spongers' operations. Attention may be drawn to the advisability of experimenting with an apparatus constructed on the principle of the so-called "deep-water oyster-tongs," by means of which oyster-beds beyond the reach of ordinary tongs become readily accessible.

The tongs in question, of which there are several types, consist essentially of two curved iron bars, riveted together near the middle to permit free motion. These are attached on one extremity to the teeth and cradles, and on the other to the ropes by means of which the apparatus is lowered and raised. Beneath the crossing-point of the two arms a weight is suspended. To the upper bar of one side an iron link or loop is attached by means of a staple, and on the lower bar, just below the link, is a small iron peg or stud over which the link fits when the teeth are separated to their widest extent. When oystering begins, the arms are locked by means of the loop and peg and the tongs lowered to the bottom. By suddenly dropping the tongs from the height of a few feet from the bottom the loop slips off the pin, by virtue of the weight referred to, and the teeth will then approach each other when the ropes are hauled taut. The weight and the loop and peg may, however, if desired, be dispensed with by attaching a line to the crossing-point of the two arms and placing weights at the upper ends of the latter, the tongs being lowered by means of the middle line and kept open by the weights mentioned.

The extreme simplicity of this apparatus is a great recommendation for its use in the oyster fishery, and suggests its employment in the sponge fishery. It is open to the objection of being somewhat heavier than the ordinary oyster-tongs, and in deep water a small windlass must be attached to the mast or elsewhere on the boat, by which it can be raised and lowered. The cost, complete, is about $15. If the principle embodied in this apparatus is found to be adapted to the sponge fishery a modification in the line of lightness and cheapness could doubtless be made. The number of teeth and the carrying capacity of the tongs required in the oyster fishery might be reduced and the apparatus made to consist practically of two opposing hooks, such as are now used in the sponge fishery.

The sheepswool is probably the most abundant of the Florida sponges, although it is not relatively so abundant as the catch of it and other species would indicate, owing to the fact that its greater value makes it more eagerly sought.

The decrease in the abundance of this species has been marked in many places. In the vicinity of Anclote Keys the grounds in 10 to 12 feet of water were exhausted before the civil war; but during the war the sponge-beds had a chance to recuperate, and later afforded some good fishing. They were very soon depleted, however, and have not since borne sponges in any noteworthy quantities. This is the general history of the "bay grounds." Deeper and deeper bottom has had to be resorted to in order to make the fishery profitable, until now some fishing is done in water as deep as 50 feet. Occasionally good fares are taken on the inshore and key grounds. The latter, in depths of 10 to 20 feet, seem to recuperate more rapidly than the bay grounds, and produce excellent crops some seasons; but they have in general shown the same depletion as other grounds, and the spongers have to work over a larger area and more assiduously than was necessary a few years ago. Even the deepest grounds now frequented are showing the effects of overfishing, and would doubtless soon prove

onproductive of marketable sponges if the weather and water were always favorable o the spongers, the preservation of the beds largely depending on the prevalence of torms or turbid water during some seasons or parts of seasons.

The sheepswool is believed by many observers to grow the most rapidly of any of ıe sponges, but information on this point is not as complete or accurate as might be esired. Some experiments performed and observations made by gentlemen of Key Vest lead them to believe that this species may, under favorable conditions, grow om the beginning to one-tenth of a pound weight in six months. The opinion that ıis sponge will grow from the spat to good commercial size in one year is practically nanimous and seems to be verified by the sponging operations. The spongers all stify that grounds which were thoroughly fished out one year are found to yield ırge numbers of commercial sponges twelve months thereafter.

The catch of the sheepswool in 1895 was fifteen times and in 1897 six times as aluable as that of all other species combined, and is thus sufficiently important to ive prominence to the sponge industry, even if no other kinds were taken. The aver-ge prices per pound brought by sheepswool sponges were $1.57 in 1895, $1.66 in 1896, nd $1.53 in 1897.

Of late, owing to a diminished supply, the relative catch of sheepswool sponges ıas been decreasing, cheaper varieties entering more largely into the receipts. In 1895 the percentage of sheepswool sponges in the total catch was 76; in 1896 it fell to 64, and in 1897 was only 47.

### THE VELVET SPONGE.

This is an uncommon form, with a very limited distribution. Along the west coast of Florida it is rarely found, the yield coming almost entirely from certain grounds among the keys. It resembles the sheepswool in general structure, but has a smoother surface and finer fibers. The characteristic feature is the presence of soft protruding cushions, whence the name. It is also known as the boat sponge. Its shape is very irregular. Its average size is 7 or 8 inches in diameter, but the diameter of some is a foot or a little over. Its principal source of supply is the region adjacent to the Matecumbe Keys, where it is taken on coral bottom in water from 15 to 20 feet deep. The grounds have undergone serious depletion, and smaller cargoes are landed each year. Velvet sponges are taken in smaller quantities than any other Florida sponges. In 1897 many dealers did not handle any, and the receipts in recent years have never exceeded a few thousand pounds per annum. The usual price paid by dealers is 50 cents a pound.

### THE GRASS SPONGES.

There are at least two species comprehended under the trade name of grass sponge, and the individual variations are numerous. One species (called *Spongia graminea* by Hyatt) has a coarse, open structure, with deep furrows on the sides, in which the afferent channels always begin. The general shape is that of a truncated cone, with the larger openings always on top. The other grass sponge (*Euspongia equina cerebriformis*) resembles one form of the yellow sponge, but differs in having its ırface marked by parallel longitudinal ridges surmounted by two or three lines of ıfts. In the depressions between the ridges the large efferent canals open, their ifices being in rows. Many forms of this species exist. The cup shape predominates.

Grass sponges are of relatively inferior quality, although largely consumed for special purposes. They are found in all parts of the sponge region, and are probably the most abundant of the Florida sponges, the annual yield not being proportional to the abundance. Large cargoes are obtained on the Rock Island, Anclote, and Key grounds. The Anclote region of late has produced the largest part of the catch, and the sponges there are of relatively good quality.

The recent increase in the production of grass sponges, especially from grounds in the Gulf of Mexico, has been noteworthy, as shown by the preceding table. In 1895 grass sponges constituted less than 7 per cent of the total yield; in 1896 the output rose to 19 per cent, and in 1897 was nearly 39 per cent. This utilization of larger quantities of a relatively cheap sponge is a strong indication of the decrease in the supply of the best quality of sponges.

### THE YELLOW SPONGE.

This ranks next to the sheepswool in quality. It corresponds with the Zimocca sponge of the Mediterranean. The dealers classify the "hard-head" sponge in this grade—a form having a darker color, harder texture, and less value than the yellow proper. The distribution of the yellow sponge is coextensive with that of the sheepswool, both growing together among the keys and on the west coast of Florida. The yellow sponge is most commonly found on rocky bottom, at depths of a few feet to over 30 feet. Those taken for market are from 4 to 10 inches in diameter, 6 to 8 inches being the average.

The yellow sponge is very abundant, but less so than formerly, especially among the keys, whence most of the supply comes, and where the grounds, being more accessible, are more assiduously fished. The key sponges are of much finer quality than those from the "bay grounds," being softer in texture and more durable. The grounds about Matecumbe Key yield an especially good grade of yellow sponge, characterized by a rich yellow color, regular shape, and superior quality. Biscayne Bay and other grounds on the east coast also produce a fine class of yellow sponges.

This species ranks next to sheepswool in the commercial scale, although it commands a less price per pound than the velvet sponge. In the aggregate the value of the catch of yellow sponges was formerly more than that of all the remaining grades except the sheepswool, but of late the grass sponge has surpassed the yellow in this respect. The average price received by sponge fishermen is about 40 cents a pound.

### THE GLOVE SPONGE.

This is the least valuable of our commercial sponges. Its fibers have a tendency to become brittle with age, it lacks elasticity, and it has very little market value. The skeleton is dense and the surface is much smoother than in the other sponges. It does not attain a large size, not often exceeding 8 inches in diameter and averaging less than 5 or 6 inches.

It is a singular and suggestive fact that this, the very poorest of our sponges, is of the same species as the very finest and best of the Mediterranean sponges, namely, the Levant toilet sponges and the Turkish cup sponges; even some of these, however, are of inferior quality. The fact is thus strikingly emphasized that the quality of sponges is to a considerable extent independent of their specific characters and depends on physical conditions.

The glove sponge has a more limited distribution than any other Florida species. It is found from Biscayne Bay to Key West, but appears to be either very rare or entirely absent on the grounds along the west coast. It grows on rocky bottom in comparatively shallow water, in company with other commercial sponges. Most of the catch is from a depth of less than 10 feet, although the species inhabits somewhat deeper water. It is taken in smaller quantities than any other standard species except the velvet sponge. This, however, is not an accurate criterion of its abundance, as it is less sought for, owing to its poor quality and small market value. It brings the spongers only about 10 to 15 cents a pound, a price so low as to discourage its gathering.

## SPONGE LEGISLATION IN FLORIDA.

The sponge laws of Florida now in force relate to the gathering of small sponges, the use of dredges, the taking of sponges by diving, and the artificial propagation of sponges, the legislation covering the last-named item having been enacted in 1897. The full texts of the laws are as follows:

Whoever dredges or uses a dredge for the catching or gathering of sponge in or upon the waters of the Gulf of Mexico within three marine leagues of the shore, or upon any of the grounds known as sponging-ground along the coast line of Florida from Pensacola to Cape Florida, or whoever gathers sponge less than 4 inches in diameter, shall be punished for each offense by fine not exceeding $500, and by confiscation of the boat, tackle, and machinery, and in default of the payment of the said fine the offender shall be imprisoned not exceeding one year. (Revised Statutes of Florida, section 2772, chapter 3615, act of 1883.)

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Whoever gathers or catches sponge in or upon any of the grounds known as sponging-grounds, along the coast of Florida, from Pensacola to Cape Florida, by diving either with or without a diving suit or armor, shall be punished by fine not exceeding $2,000, and by confiscation of all diving suits or armor, boats, and vessels used in such unlawful gathering of sponge, and in default of the payment of said fine the offender shall be imprisoned not exceeding one year.

The fact of having one or more diving suits or armors on board of any vessel or boat in and upon any of the grounds known as sponging-grounds along the coast of Florida, shall be prima facie evidence of the violation of the preceding section.

Whenever an officer arrests any person charged with an offense which, by the provisions of this article, may be punished by the confiscation of the vessel, boats, crafts, nets, seines, tackle, or other appliances used in such unlawful act, it shall be his duty to seize the same and take them into his custody to await the sentence of the court upon the trial of the offender.

If the offender be convicted, the court in awarding sentence shall make an order confiscating the said vessels and implements, and authorizing the executive officer of the court to sell them, after due notice, at public auction to the highest bidder. If the accused be acquitted, the said vessels and implements shall be returned to him. (Revised Statutes of Florida, sections 2773, 2774, 2775, 2776; chapter 3913, act of 1889.)

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An act to protect and encourage the artificial growth of sponges within the waters of the State of Florida, and conceding certain riparian rights to those engaged therein, and to prescribe a license in certain cases.

*Be it enacted by the legislature and State of Florida:* It shall be lawful for any person or persons owning lands bordering upon the waters of the State to propagate and grow sponges in the waters in front of such lands, to depth not exceeding 1 fathom at low tide, and they shall have the exclusive right to sponge or propagate and grow sponges within such limits: *Provided,* That in no case shall this right extend beyond 300 yards from the shore line.

SEC. 2. Any person or persons owning lands bordering upon the waters of any bay, lagoon, sound, or strait, shall, within their headline, have the exclusive right to sponge, propagate, or grow sponges

within such waters to a depth not exceeding 1 fathom at low tide: *Prorided*, That this exclusive right to grow and propagate sponges shall not extend beyond the distance of 300 yards from the shore line. And when different persons own lands upon the opposite sides of such waters, and the depth thereof does not exceed 1 fathom, then the lines shall extend from lines drawn across their respective headlines to another line equidistant from the lines drawn across such headlines.

SEC. 3. It shall be lawful for any person or persons owning lands as described in the preceding sections, or surrounding any basin, bay, or lagoon not exceeding 1 fathom in depth at low tide, to inclose or stake off the waters in front of such land, not exceeding the distance of 300 yards from the shore line, for the purpose of protecting and marking the waters to which they are entitled, and they shall have the sole and exclusive right to sponge, propagate, and grow sponges within such limits out to a depth in front of such lines drawn through the headlines of their respective lines, and they shall have the right to post such inclosures and warn off trespassers: *Prorided*, That no one shall obstruct the waterways necessary for the purposes of navigation, and that no right or privilege shall extend across or beyond any waters used for navigable purposes: *Provided further*, That the rights and privileges mentioned in this act shall only extend to those persons who are actually engaged in the business of raising and propagating sponges.

SEC. 4. That nothing in this act shall be construed as interfering with the rights of any person or persons to fish for fish or oysters in or upon said lands.

SEC. 5. Any person or persons who shall willfully and maliciously destroy, deface, or break down any sign, fence, gate, inclosure, or staked place for the purpose of defining and protection of waters used for sponge-culture shall, upon conviction, be punished by imprisonment in the county jail for a period not to exceed six months, or by fine not to exceed $500.

SEC. 6. It shall be lawful for any person or persons engaged in the business of artificial growth of sponge to gather sponges of any size to be used solely and exclusively for the purpose of transplanting.

SEC. 7. That any person not a citizen of the United States who shall engage in the business of sponge fishing, either for himself or any other person, shall, before entering into said business, pay an annual State license of $25. Any person violating the provisions of this section shall, upon conviction, be fined in a sum not to exceed $50, or be imprisoned in the county jail for a period not to exceed sixty days. (Act of May 12, 1897, chapter 4564.)

## EVIDENCES AND CAUSES OF A DECREASE IN THE SPONGE SUPPLY.

Although the sponge fishery of Florida is only forty-five years old, the sponge-grounds are on the whole much less productive than formerly, as is acknowledged by practically everyone who is in a position to express an intelligent opinion. Of course there are still very important grounds among the keys and on the west coast of the State, and sponges still exist and are taken in very large quantities; but the efforts now made would result in a vastly increased catch if the sponges were found in anything like their original abundance. There are many points of similarity between the history of the Florida sponge-grounds and that of the oyster-grounds of some States in which dependence has been chiefly placed in the natural beds for supplying the demand. In confirmation of the diminution of the sponge supply, the following facts may be cited:

1. There has been a complete abandonment of some grounds formerly productive, especially the inshore grounds, which were the only ones resorted to in the early days of the fishery. The depletion naturally began in the shoaler waters, where sponges could be more easily gathered, and has gradually extended so as to embrace, to some degree, all available grounds.

2. The fishery has had to be prosecuted in deeper and deeper water in order to maintain the catch, until the maximum depth in which sponging is possible with present methods has been reached. Beyond 50 or 52 feet it is practically impossible to pull sponges with appliances now in use, although in the Mediterranean sponging is done in water as deep as 70 feet by using improved poles.

3. In general there has been a smaller catch per man and per vessel. Very many trips result in a loss to the owners or outfitters of the vessels, and it is now the exception for a vessel to bring in the average catch of earlier years.

4. The catch is very noticeably made up of small sponges, those under the legal size constituting a too prominent proportion.

The causes for the decrease are readily determined and are almost unanimously recognized by spongers and buyers. They are directly traceable to indiscriminate fishing, although stress is laid on natural agencies by some of those interested.

### TAKING OF SMALL SPONGES.

This is undoubtedly the principal cause of the decrease in the supply of Florida sponges. While the State law, which has now been in force fifteen years, expressly forbids the sale of sponges less than 4 inches in diameter across the top, the law has never been seriously regarded by fishermen, dealers, or sheriffs, and the occasional spasmodic efforts made to enforce it have only added to the disrepute in which the statute is held. It is extremely doubtful if the law has resulted in the saving of a single undersized sponge or the slightest protection of the grounds. The attempt to remind the spongers of the existence of the law has usually been on the arrival of the fleet, when the damage has been done, and by the time vessels have returned to the grounds the law has been conveniently forgotten by law officers and law breakers alike.

Some figures are available which illustrate the great damage done to the industry by the gathering of small sponges, and show how short-sighted the fishermen are in this respect, and emphasize the necessity for a change in the present status.

The very small sheepswool sponges which the fisherman bring in, many of them only half the legal size, have little market value. When a sponge-buyer purchases a cargo these small sponges receive scant consideration and are often entirely discarded in determining the value of the lot. When undersized sponges are sold independently it has not infrequently happened that 20 bunches or strings, each holding 25 sponges, have brought the fishermen only $1 or $2. The same sponges if left on the grounds six months longer would have been worth $150 to $175. A case is cited in which 1,250 sheepswool sponges were sold in Key West for $5. Conservative estimates indicated that if left down six months longer these would have brought at least $390.

It is a very small sponge which the average sponge fishermen will now discard, and yet, on the authority of reputable dealers, it may be stated every season there are many thousands of sponges gathered which never reach the markets, but are thrown away. It may be safely asserted that each year the small sponges taken from the Florida grounds would add $100,000, or 30 per cent, to the value of the product if they could be left growing for six months.

### EXCESSIVE FISHING.

Coincident with the gathering of small sponges has been the excessive sponging on grounds, season after season, without any regard whatever for the preservation of enough stock to secure the repopulation of the beds. A sponge fisherman will rarely willingly or knowingly leave any sponges of value on a ground; and the entire history of the sponge industry shows a flagrant disregard for the preservation of the supply.

It can scarcely be wondered at, therefore, that there is more difficulty each year in obtaining good cargoes, and that the output is decreasing. An average cargo now is only a half or a third what it was ten or fifteen years ago.

## POISONOUS WATER.

A factor in the decrease in the sponge supply to which many of the spongers attach much importance is the so-called "black" or "poisonous" water. Its nature is not definitely established. Some think it is water from the Everglades, discharged into the Gulf in unusual quantities; others that it is due to submarine volcanic disturbances, resulting in the liberation of noxious gases. Whatever the cause, it is certainly destructive to all forms of life, and it is known to have depleted some very productive grounds. Fortunately this kind of injury is of infrequent occurrence, seldom coming in serious form oftener than once in a decade. Of the very disastrous poisonous water plague in 1878, the following account has been given:

The earliest indication of it was the floating up of vast quantities of dead sponges, chiefly loggerheads. The dead sponges were first noticed less than 40 miles north of Key West, but it was soon discovered that all the hitherto profitable sponging-grounds lying off the coast, as far north nearly as Cedar Keys, and particularly off the Anclotes, had been ruined. These grounds had only begun to show signs of recuperation as late as 1882; their abandonment from the reefs to Cedar Keys, during the three or four years which followed the occurrence, entailed a loss estimated at $100,000. Had it not been for the fortunate discovery, just at that time, of sponge tracts off Rock Island, northward of the Suwanee River, almost a famine in this article would have ensued.[1]

Too much stress, however, is now laid on this condition as a factor in the diminished supply during recent years.

## REMEDIAL MEASURES.

With anything like fair treatment there is no reason why the Florida sponge-grounds should not only support the present drains, but permit much more extensive fishing than is now possible. The area of the grounds is so large, estimated to be over 3,000 square miles, and the growth of the sponges is so rapid that with proper precautions there is hardly a limit to the productive capacity of the beds.

Foremost among the remedial measures that are demanded I place the enforcement of the law relative to the gathering of small sponges. It is probable that the statute should be slightly modified, so as to make it more readily executed; it would doubtless be improved by having it prevent the landing or sale of undersized sponges. It is said that there is some question as to the State's jurisdiction over grounds lying beyond a marine league; if so, it is an additional reason for amending the law as indicated.

It is claimed by some that such a law is difficult to enforce, especially after years of flagrant violation. To this I take exception, and believe that the law will almost enforce itself if the State will show any disposition to encourage its observance. The sentiment in favor of the law and its impartial enforcement is remarkably strong. Dealers and vessel-owners, and others having pecuniary interests at stake, are unani

[1] The Fishery Industries of the United States, sec. v, p. 831.

mous in the belief that the law is wise and beneficial in principle and that it should be enforced; and very many of the sponge fishermen entertain the same opinion. With this feeling prevailing among the sponge interests, the question very naturally arises, Why do not the buyers and outfitters observe the law even if the State regards it as a dead letter? The answer is that as long as such small sponges have any market value the fishermen will take them to fill out their cargoes, especially when large sponges are scarce. When sponges are once landed there is no reason for buyers to refuse to take them, especially as they pay very little for them.

The statement is confidently made that if the State officers in each sponging center should announce that the law would be enforced against all vessels and boats which sailed after the date of the notice, within six months a new order of things would be firmly established, to the benefit of all concerned.

The opinions of the fishermen themselves as to remedial measures should not be given too much weight. Very many of them are aliens (Bahama negroes), and few of them have any pecuniary interests at stake. The men owning vessels and having capital invested in the sponge trade are those whose views are entitled to consideration.

The present legal minimum size of sponge is almost unanimously regarded as too low by those pecuniarily interested. A sponge 4 inches in diameter across the top is very small and has little market value. There is a general sentiment favorable to an increase of the legal size to 5 inches, and some persons favor even a larger standard.

In order to permit the recuperation of the exhausted grounds and prevent the absolute depletion of beds, the prohibition of sponging on certain grounds for definite periods has been suggested, and meets with general approbation. A sponge merchant of Key West, who has devoted much attention to the subject, writes as follows regarding this matter:

> Let nature do its work by allowing it sufficient time. This can be done by dividing the area of the sponge-grounds at sea into squares each of 100 miles, more or less, and then allowing the fishermen to gather sponges only in certain squares each season of the year. According to all reports, on some grounds sponges grow much faster than on others. They have been noticed to grow to full size inside of four months in certain localities along this coast, while at other localities it takes young sponges at least six months to grow to full size. This fact can be put to advantage by restricting sponge gathering during several months on certain grounds, during which time the sponge fisherman can gather sponges on the other parts of this coast. However, as it is necessary to the sponge fishermen to have not only good weather, but also clear water, so as to enable them to see the bottom and to locate the sponges, it may happen that when they are out on their expeditions they may meet with muddy water on the unrestricted sponge-grounds of the season, while on the restricted grounds during that season the water may be clear and just in condition to allow them to locate and to gather the sponges. As the benefit that sponge fishermen could derive from the above restriction of certain grounds during certain seasons of the year would soon be important and lasting, it seems to me that no proper objections could be offered to the method.

In a report[1] on "The Fish and Fisheries of the Coastal Waters of Florida," the United States Fish Commissioner suggests that sponging on the grounds of Biscayne Bay and the Florida Keys be permitted only during a specified part of any period of twelve months, and that fishing on either the Anclote or Rock Island grounds be allowed only once in any period of twenty-four months, so arranged that the Anclote

[1] Senate Document No. 100, Fifty-fourth Congress, second session; also Report U. S. Fish Commission for 1896, pp. 263-342.

region may be open to unrestricted fishing one year and the Rock Island grounds the next.

Whatever action is finally taken by the State in this matter, there should be a careful preliminary investigation by a competent board, which should inquire into the special conditions in the different parts of the sponge region and determine the boundaries of the areas to be successively brought under restrictive provisions.

A final remedy for arresting the decrease in the sponge supply is the cultivation of sponges, the necessity for which depends to a large degree on the carrying out of the foregoing measures.

## CULTIVATION OF SPONGES FROM CUTTINGS.

The growing of sponges from clippings may be said to have almost passed beyond the experimental stage, since the possibility of the procedure has been amply demonstrated. At the same time, the business of producing marketable sponges from clippings has not been engaged in, although there seem to be no insurmountable difficulties in this country at least; and the present indications are that before five years have elapsed private sponge-farms will have become established on parts of the Florida coast.

There are various reasons why the artificial growing of sponges should receive attention. In the first place, sponge-culture should partly arrest the further depletion of the natural grounds by diverting the energies of some of the spongers in the direction of the possibilities of the now barren grounds. If the cultivation of sponges becomes established along the many hundreds of miles of suitable coast, it will certainly prove a profitable employment to a large number of people, either independently or in connection with other branches of industry. Furthermore, the increase in the output which must follow the successful inauguration of sponge-culture will reduce the dependence of the United States on foreign sponges. Finally, the State may with great propriety obtain a revenue from this source.

The lines along which the planting of sponges must be conducted have been indicated in the different experiments already made, to the printed accounts of which those especially interested are referred.[1] No detailed statement of the methods employed by various experimenters is necessary for the purpose in view in the present paper.

It may be stated, however, that thirty-five years ago the question of artificial propagation of sponges received attention in Europe and was under consideration for ten years; that nearly twenty years ago limited experiments were conducted at Key West; that in 1889, 1890, and 1891 some very interesting trials were made in Biscayne Bay; and that at present the matter is receiving serious attention in the vicinity of Key West, where planting has begun on a commercial basis.

While the work of Mediterranean experimenters was of a more systematic and

[1] Reference is especially made to the following articles: (1) Experiments in sponge-culture at Key West about 1880: The Fishery Industries of the United States, sec. v, vol. 2, p. 832. Reprinted in Senate Document No. 100, second session, Fifty-fourth Congress, being a report of the United States Fish Commission on the coast fisheries of Florida. (2) Sponge-cultural experiments in the Adriatic Sea, 1863-1872: Die Aufzucht des Badenschwammes aus Theilstücken, by Dr. Emil von Marenzeller, Vienna, 1878. An abridged translation appears in the Fishery Industries of the United States, sec. v, vol. 2, pp. 833-836; the latter is also reprinted in the Senate document named. (3) Account of Sponge-cultural experiments in Biscayne Bay, 1889-1891, by Ralph M. Munroe. Contained in Rep. U. S. Fish Com. 1895, pp. 187, 188.

prolonged nature than that of our own countrymen, it can not be said that their results were as striking or encouraging. Their studies, which were supported by the Austrian Government and merchants of Trieste, were finally abandoned, owing to the hostile attitude and depredations of the fishing population.

The following are some of the special facts that have been established by the experiments in this country and abroad:

(1) Sponges may be cut into small pieces, which will live and grow if properly attached in suitable water. They may be cut in water or on a moistened board with a knife or fine saw. Care must be exercised not to express the soft matter. The preferred size of the cuttings is about an inch broad and a little more in height. The outer skin is to be retained as far as practicable. In cutting, the lines of the circulating canals should probably be considered, although pieces cut without any reference to the direction of the canals have lived and grown.

(2) Exposure of the sponge to the air in making and fixing the cuttings is not injurious, unless prolonged or in very warm weather. This is contrary to a prevalent impression, but seems to be amply proved. Mr. Munroe, in his experiments in Biscayne Bay, found that clippings from sponges that had been exposed several hours lived and grew; and in the Adriatic Sea sponge cuttings kept out of water, in a shady place, for eight hours in February, the air temperature being 48° F., took root when planted. It is probable, however, that in the case of larger sponges, when removed from their element, the weight of the contained water may have a crushing effect on the soft parts concerned in nutrition and thus retard growth in the clippings subsequently made therefrom. In a high temperature the sponges have a tendency to rot, hence the winter is regarded as the best time for planting.

(3) Clippings may be made from distorted sponges having little market value, and will assume a symmetrical shape during growth. A healthy cutting will become firmly attached to a surface comparatively soon if it does not move. Even as short a time as 24 hours has been sufficient, in the European experiments, to secure attachment during the prevalence of warm weather.

(4) The possible methods of attachment are various. This is a very important step, and probably the ideal practice is still to be determined. The things to be accomplished are: (*a*) to make the clipping fast pending the time when it will naturally take root; (*b*) to employ for this purpose some material that is not injurious to the sponge and will not distort its growth; (*c*) to place the attached clippings on the bottom in such a way that they will maintain the upright position and not be smothered by mud, sand, or sediment. The sponge clippings have been attached to boards, frames, poles, and different kinds of wire. The wooden parts are liable to attacks of worms, and some kinds of wire are injurious because of the chemical decomposition that ensues in salt water. The use of bamboo pegs seems to have given much satisfaction.

In Europe, the cuttings appear to have been placed at depths of 16 or 23 feet, light being considered an objection, but in Florida the experiments have been conducted in water from 8 feet to less than 1 foot deep at low tide, and good results have been had at the shallowest depths.

(5) The rate of growth in Florida waters is comparatively rapid. It is a common experience of spongers to find marketable sponges on grounds that had been thoroughly depleted of all salable sponges in the previous year, and the results of

experiments bear out this point. In as short a time as one year, under favorable conditions, the cuttings will attain a marketable size, and certainly within sixteen or eighteen months the harvesting of relatively large sponges may be depended on. These results are in marked contrast to those in the Adriatic, where the rate of growth was so exceedingly slow as to seriously militate against the feasibility of sponge propagation in those waters. The person in charge of the experiments states that "the clippings grow two or three times their original size during the first year," and that, "although some pieces will grow to a considerable size in five years, it will require seven years to raise completely matured sponges which are fit to become an article of merchandise." A writer who reviewed the experiments very pertinently remarked:

> The profitableness of sponge-culture would be far more evident if there was not such a long interval between planting and harvesting; in other words, if the sponges would grow more rapidly. This was certainly looked for when the enterprise was started; but it is dispiriting to have to wait for your crop for seven long years.

The attitude of the State toward the project to increase the supply of sponges by artificial means must necessarily exert considerable influence on its success. Adequate encouragement and authority should be given by the Commonwealth to those desiring to engage in this enterprise, to be supplemented by ample protection from poachers after grounds have been planted.

Artificial sponge-grounds are susceptible of the same methods of regulation that have proved of value in the case of the oyster. The State might levy a tax, which would defray the expenses incurred in protecting the growers, but if such action is calculated to discourage the business it should not be broached until the industry has been placed on a substantial footing.

The area of barren bottom which one person may be allowed to appropriate should be limited, so that no monoply will be created and the undertaking of the enterprise by numerous small planters be encouraged. The project is popular with many of the persons already interested in the sponge industry. Some, however, have expressed the fear that the best planting-grounds will fall into the hands of a few persons, who may in time secure control of the industry. The fear also exists among some of the sponge fishermen that extensive planting may deprive them of a livelihood, but there is little or no basis for such apprehension. Sponge-planting will give employment to many additional persons, and probably will indirectly prove of benefit to those who sponge on the natural grounds, by diverting some attention therefrom and permitting a larger growth thereon.

## PROPOSED INTRODUCTION OF MEDITERRANEAN SPONGES.

While for general purposes there is no better sponge than the Florida sheepswool, some of the foreign sponges, used in surgical practice and in other special branches, are more delicate, and yield a much higher price per pound than any native species. Some of the small Levant toilet sponges bring as much as $50 a pound, and the consumption of these high-priced sponges in the United States is quite large.

The possibility of transplanting in our own waters some of the best of the foreign sponges, in order that our own fishermen may reap the benefits of the high prices, opens up a very interesting subject. It has been thought that a very small colony, properly nurtured, would, under favorable conditions, form a nucleus from which a

large area might eventually be stocked. This subject has been discussed to some extent by those interested in the sponge industry, and the United States Fish Commission has been urged to make the experiment. The transplanting of Mediterranean sponges to the Bahamas has also been under consideration in Great Britain.[1]

The transportation of Mediterranean sponges to this country would involve difficulties which readily suggest themselves. There seems little doubt, however, that the project would be practicable by the use on the transporting vessel of tanks in which water could be kept aërated and of a suitable temperature.

If the acclimatization of Mediterranean sponges in Florida waters were accomplished the ultimate results of the experiment would still be problematical. It is a question whether, under the changed and less favorable environment, the introduced sponges would retain their superiority, or at least exhibit it in their offspring. Mr. Bidder states that the calcareous sponges exhibit a remarkable susceptibility to changes in environment, and thinks it not impossible that the progeny of the imported sponges would be similar in quality to the native sponges. The experiment is, however, worthy of the attempt.

There is a remarkable similarity between the marketable sponges of Europe and those of America. Hyatt thinks it evident that the Mediterranean sponges originated in the Caribbean Sea. The three leading American species (sheepswool, yellow, and glove) correspond respectively with the leading sponges of Europe (horse, Zimocca, and bath).

As to the cause of the superiority of the best Mediterranean sponges over our native sponges, there is some diversity of opinion, and different factors probably have their influence. An eminent American authority in considering this question expresses the opinion that the superiority may be due in part to the greater depth at which the Mediterranean sponges are taken, the deeper water being of better quality than the shallower, because freer from sediment, which is detrimental to the growth of the finest grades of sponge. Milky water (i. e., water made opaque by sediment) is incompatible with the best quality of sponge. While the coral reefs of the Florida coast, as in the Mediterranean, furnish excellent material for the attachment of sponges, the reefs in our own country are more exposed than in the Mediterranean, and large quantities of limy sediment are washed from them by the waves, a condition which does not exist to a conspicuous degree in the Mediterranean, where the coarsest species of sponges are found at those depths and in those situations exposed to the injurious influence of suspended matter. In the case of different grades of the same sponge the coarsest are in the shallower water. Coarseness consists in the greater stiffness and harshness of the skeleton, and is usually associated with a looser or more open structure—that is, a greater number of canals. It is this latter feature that is perhaps the most constant difference between the best Mediterranean sponges and the best Florida sponges.

The finest Mediterranean sponges grow in water having a surface temperature in winter of 50° to 57°, the mean air temperature at that season being from 63° to 70°. The sponges which occur in deeper water off the coast probably are not exposed to a colder temperature than 60° or perhaps 50° in January.[1] This differs considerably from the conditions on the southern coast of Florida, as shown by the following table,

[1] Note on projects for the improvement of sponge fisheries, by George Bidder. Journal Marine Biological Association of the United Kingdom, IV, No. 2, Feb., 1896.

which gives the temperature of the air and surface water as observed at three lighthouses in the sponging region. It is stated by Bidder (loc. cit.) that "the Levant variety lives where the atlas shows a mean annual [air?] temperature of about 7° F. below that of Florida, and the Adriatic variety at a mean temperature of about 7° F. lower still."

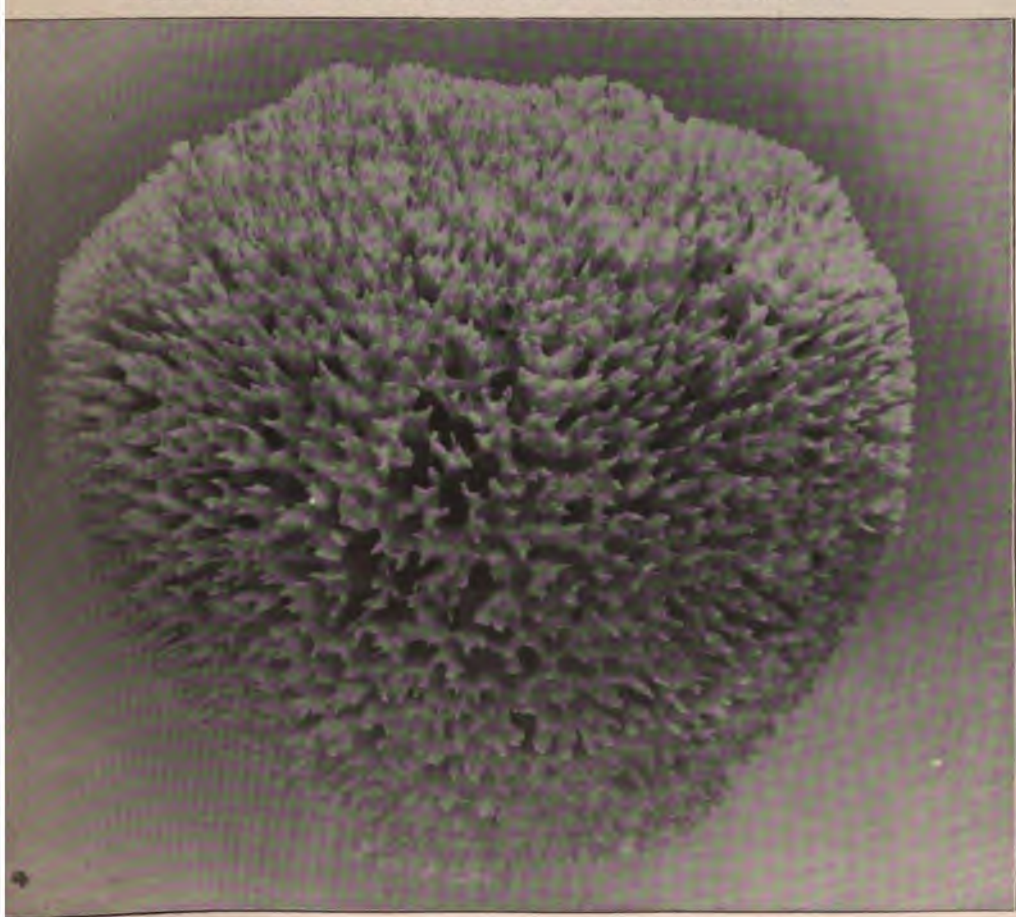
*Statement of the mean air and surface water temperatures at points on the coast of Florida in the vicinity of the sponge-grounds.*

[Depths of water where observations are made: Fowey Rocks, 5 feet; Carysfort Reef, 3½ feet; Dry Tortugas, 4 feet.]

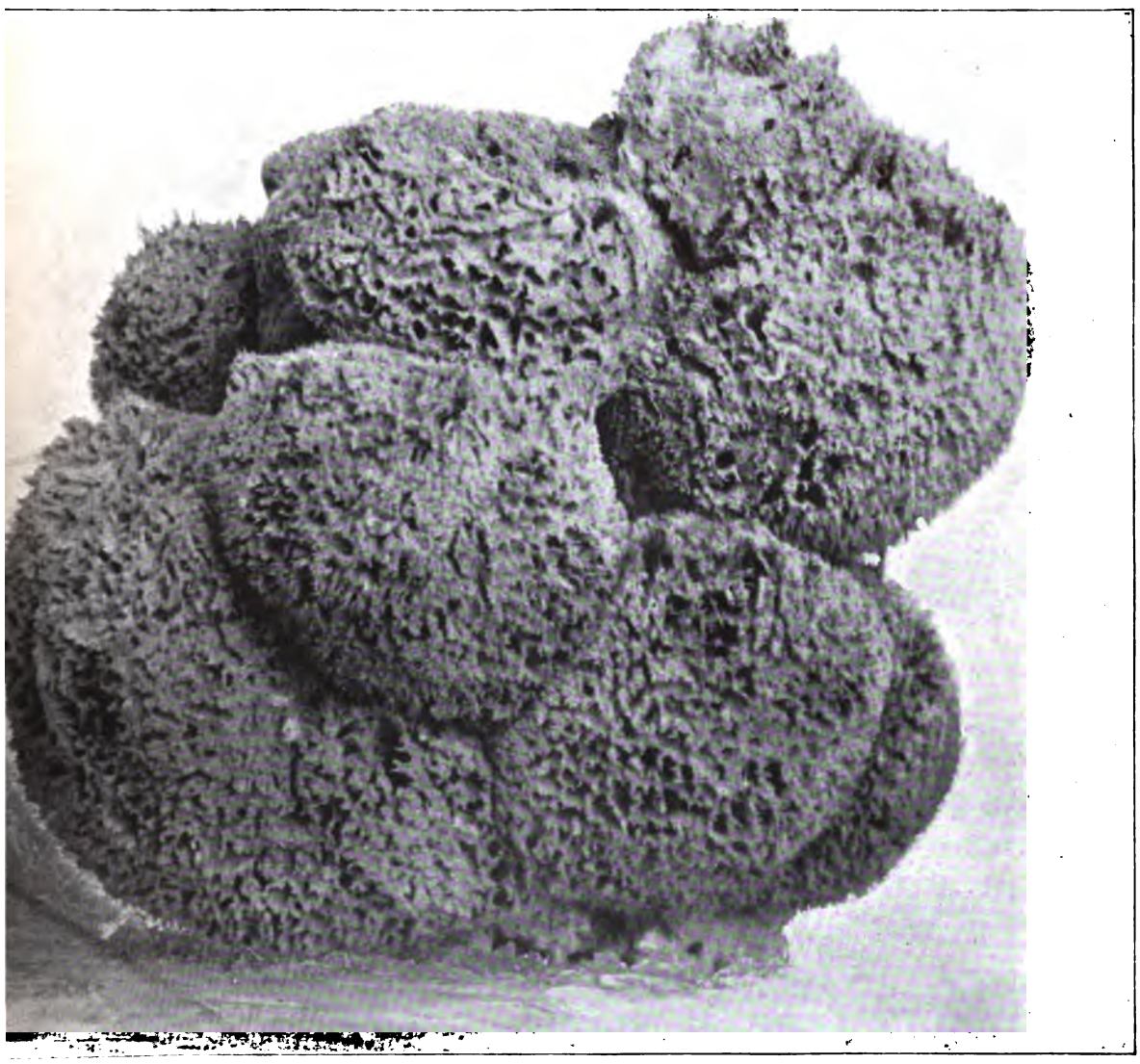
| 1895. | Fowey Rocks. | | Carysfort Reef. | | Dry Tortugas. | | 1896. | Fowey Rocks. | | Carysfort Reef. | | Dry Tortugas. | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Air. | Water. | Air. | Water. | Air. | Water. | | Air. | Water. | Air. | Water. | Air. | Water. |
| | ° F. | ° F. | ° F. | ° F. | ° F. | ° F. | | ° F. | ° F. | ° F. | ° F. | ° F. | ° F. |
| January.... | 70.41 | 72.96 | 70.95 | 71.98 | 71.47 | 73.03 | January.... | 74.60 | 69.18 | 69.20 | 72.20 | 68.93 | 70.17 |
| February... | 68.87 | 68.71 | 64.17 | 70.45 | 66.48 | 67.93 | February... | 72.38 | 70.47 | 69.38 | 72.31 | 68.87 | 70.15 |
| March..... | 73.23 | 73.45 | 72.32 | 72.16 | 73.87 | 73.41 | March..... | 76.85 | 72.13 | 72.37 | 72.05 | 71.22 | 70.43 |
| April..... | 75.50 | 74.78 | 75.35 | 73.53 | 76.20 | 74.98 | April..... | 76.40 | 75.10 | 77.37 | 76.45 | 76.41 | 75.61 |
| May..... | 78.40 | 78.18 | 79.85 | 78.45 | 81.27 | 80.07 | May..... | 83.77 | 79.60 | 80.50 | 78.31 | 81.02 | 79.41 |
| June..... | 80.35 | 79.38 | 83.22 | 81.73 | 83.25 | 81.01 | June..... | 85.85 | 82.66 | 83.47 | 81.90 | 82.82 | 82.01 |
| July..... | 82.83 | 82.70 | 86.60 | 85.40 | 84.32 | 84.01 | July..... | 86.48 | 85.23 | 84.80 | 83.90 | 83.25 | 82.60 |
| August..... | 83.93 | 83.75 | 84.42 | 84.30 | 85.05 | 84.97 | August..... | 88.58 | 86.58 | 85.88 | 87.74 | 85.92 | 85.73 |
| September.. | 84.47 | 84.70 | 84.13 | 84.31 | 84.33 | 84.60 | September.. | 87.53 | 86.16 | 85.03 | 83.73 | 84.13 | 84.88 |
| October..... | 79.47 | 78.88 | 82.75 | 81.38 | 81.27 | 80.97 | October..... | 83.15 | 82.18 | 82.62 | 81.15 | 81.98 | 81.08 |
| November.. | 75.82 | 75.88 | 77.50 | 77.48 | 77.87 | 78.13 | November.. | 83.45 | 82.00 | 80.90 | 79.51 | 77.75 | 79.28 |
| December... | 74.58 | 71.64 | 69.75 | 73.54 | 70.75 | 73.45 | December... | 77.11 | 72.62 | 72 63 | 75.68 | 71.95 | 74.60 |
| Annual mean. | 77.31 | 77.08 | 77.58 | 77.89 | 78.01 | 78.04 | Annual mean. | 81.32 | 78.66 | 78.68 | 78.49 | 77.86 | 77.99 |

WASHINGTON, D. C.

SHEEPSWOOL SPONGE. From Matecumbe Key. Diameter, 8¼ inches; weight (dry), 2¼ ounces.

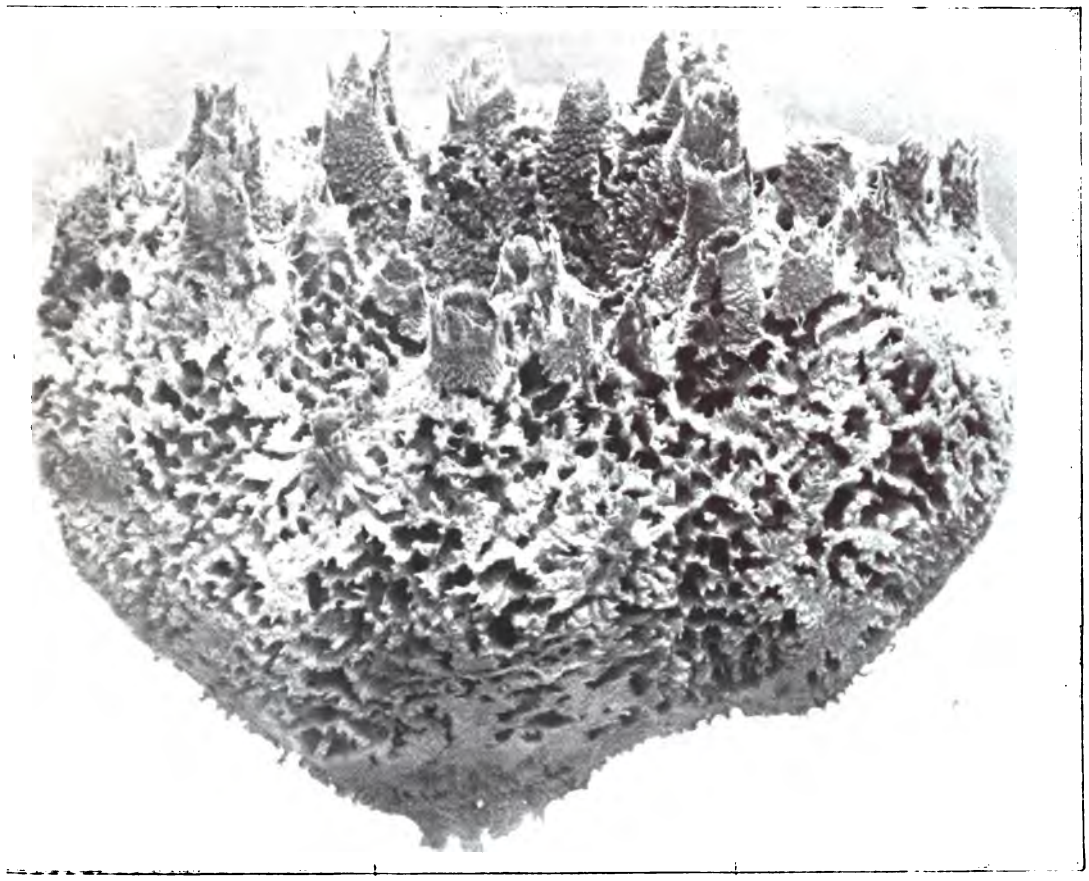


SHEEPSWOOL SPONGE. From Florida Keys. Diameter, 7 inches; weight (dry), 1¼ ounces.

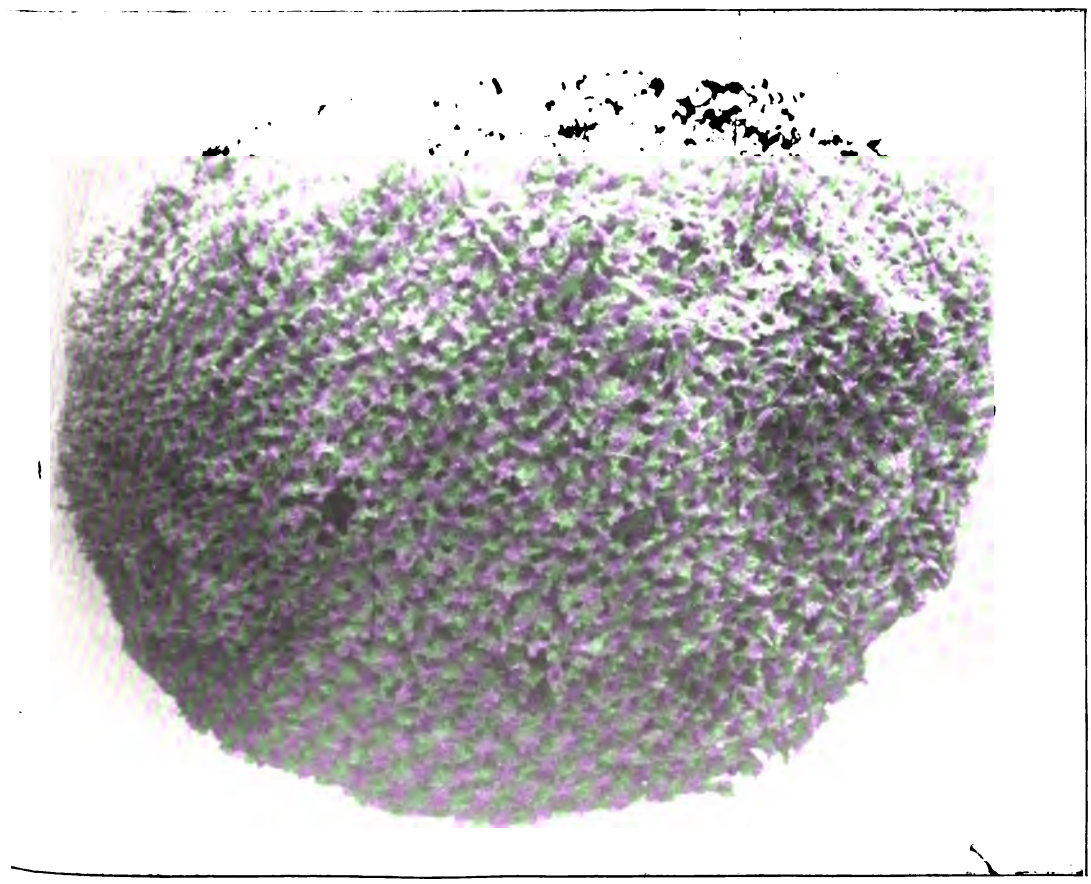


CLUSTER OF CONNECTED SHEEPSWOOL SPONGES

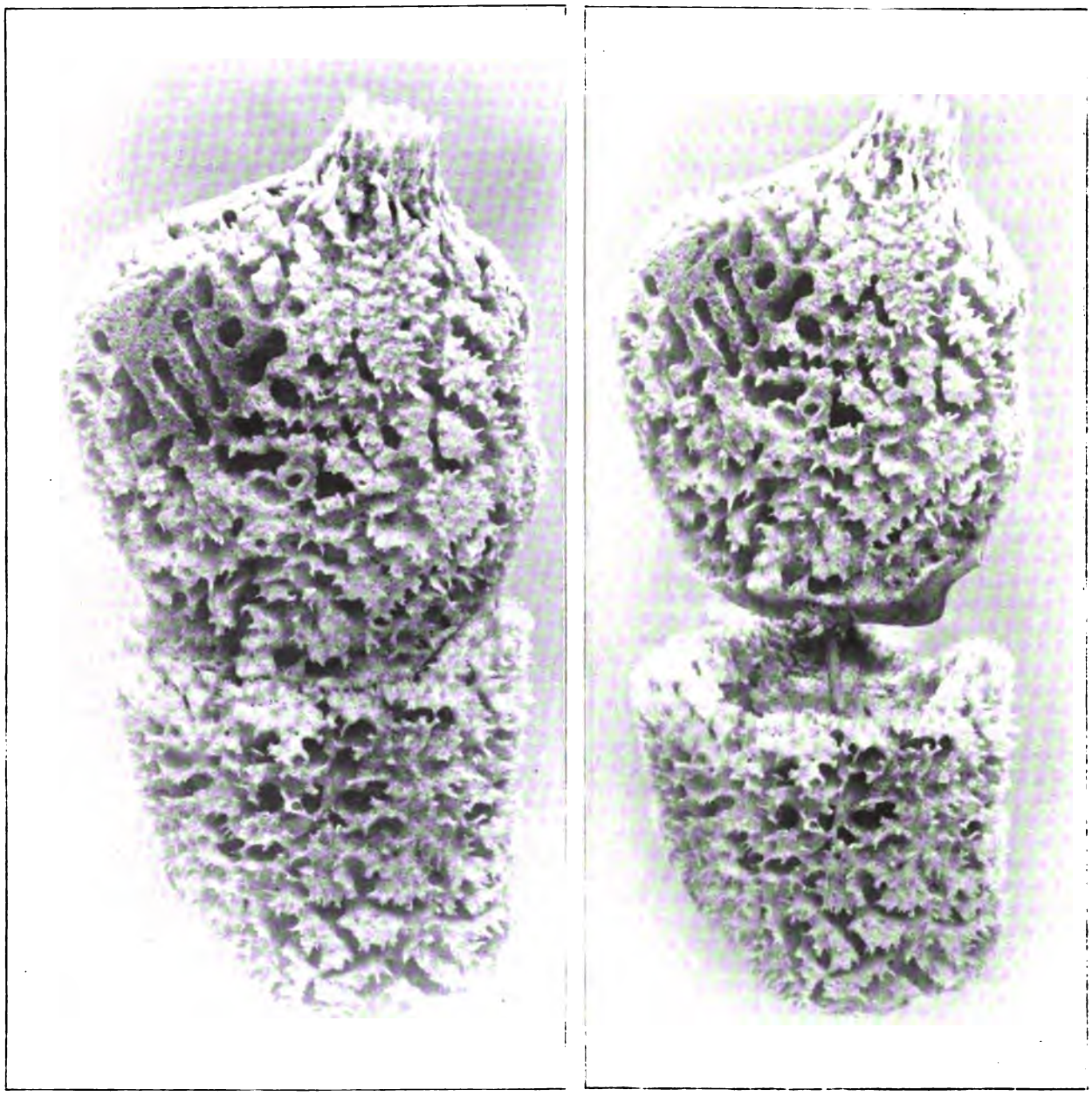
Taken near Cedar Keys, Florida, 1896, in 34 feet of water. Circumference, 6 feet 2 inches.



SHEEPSWOOL SPONGE. From Florida Keys The craters or oscula very prominent. Diameter, 12 inches; weight (dry), 5¾ ounces.

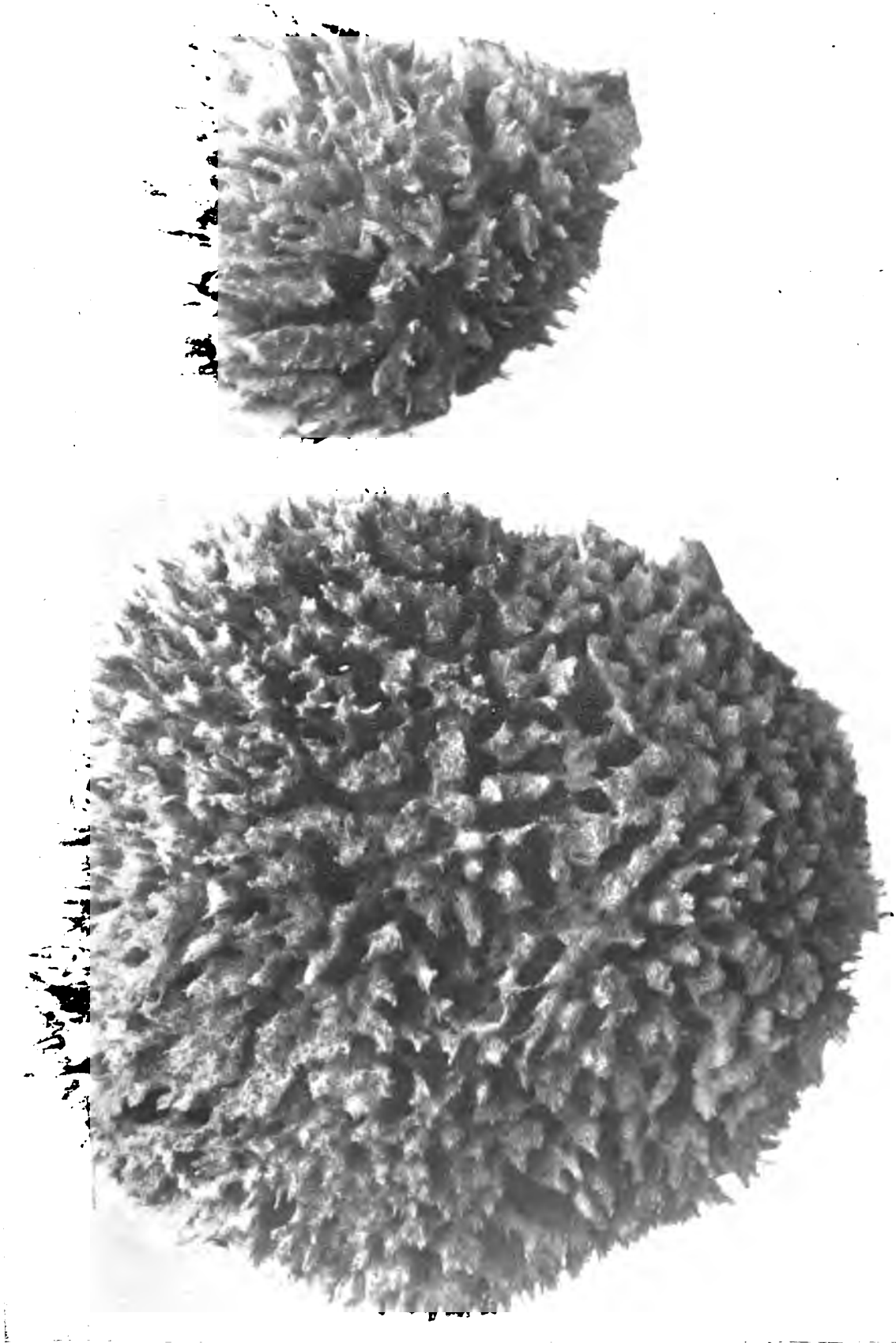


"WIRE" OR "BASTARD SHEEPSWOOL" SPONGE. Diameter, 9¼ inches; weight, 4½ ounces.



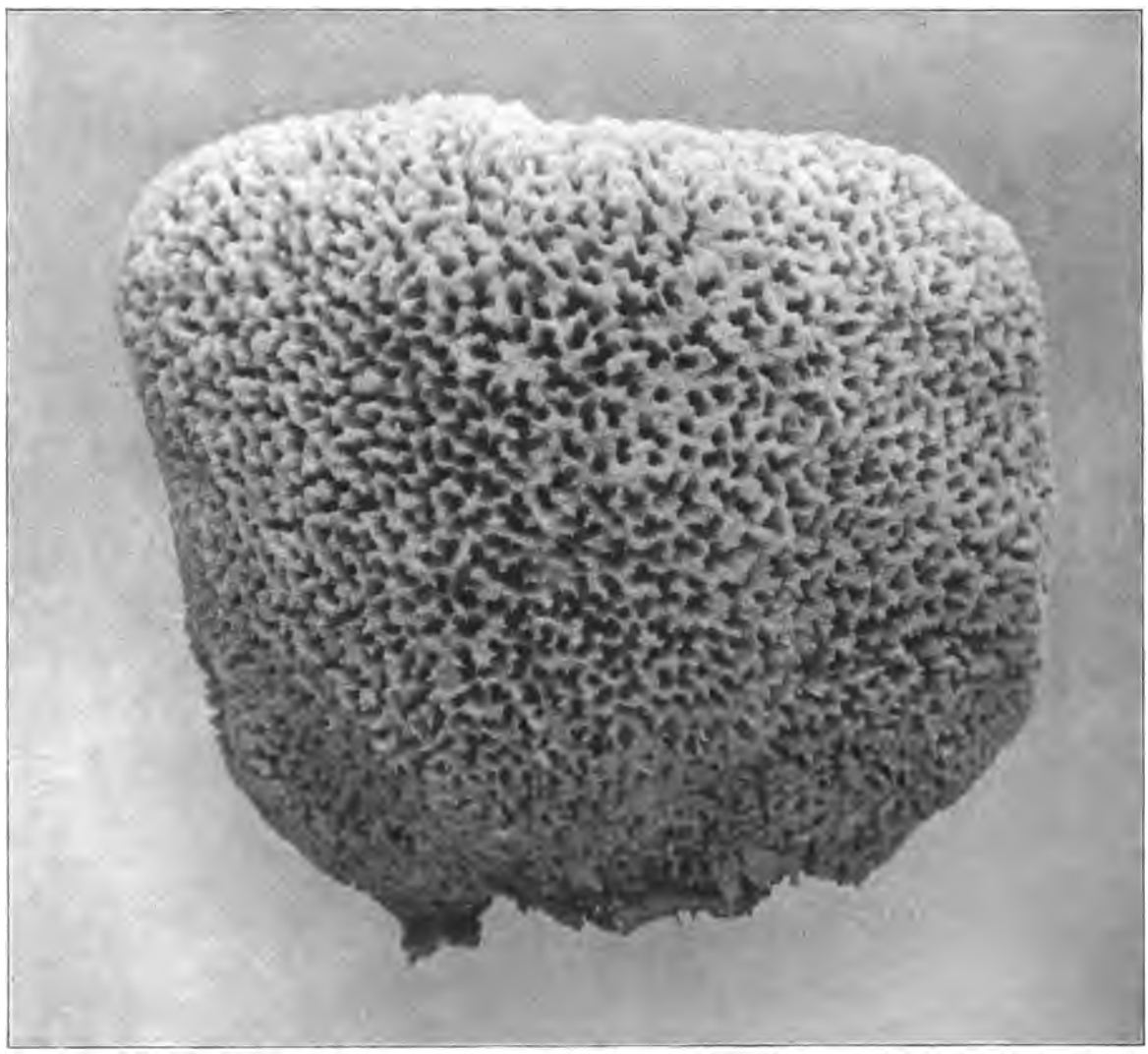
SHEEPSWOOL SPONGES.

One growing on top of the other and both perforated by the stem of a sea feather. About two-thirds natural size.



SHEEPSWOOL SPONGES. (Natural size.)

ly grown from clippings. Larger sponge planted in May or June, 1897, and taken up in January, 1898. Smaller sponge planted in August, 1897, and taken up in January, 1898. Grown in 4 feet of water in sound near Key West

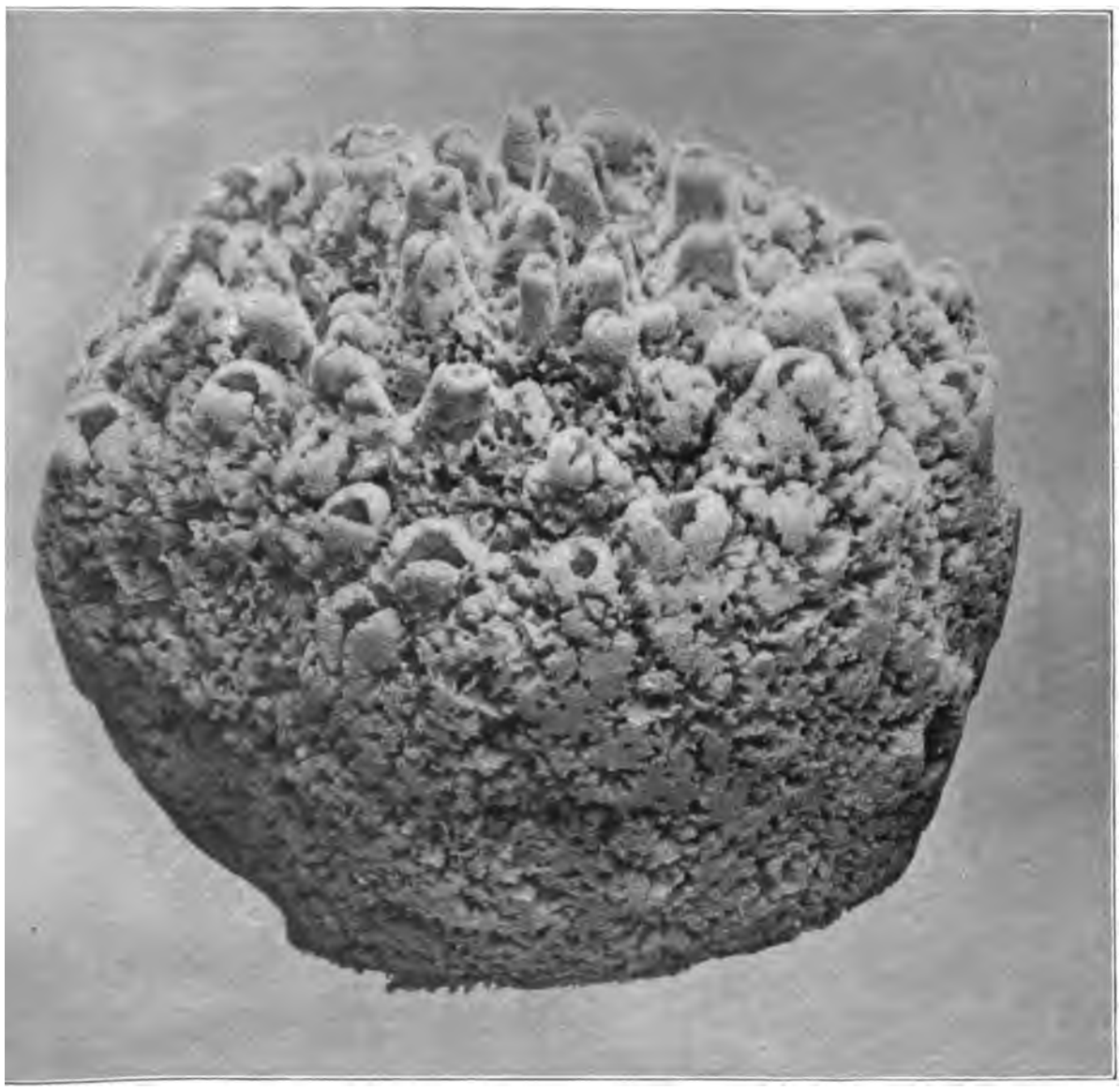


VELVET SPONGE.

From Florida Keys. Diameter, 11 inches; weight (dry), 5½ ounces.

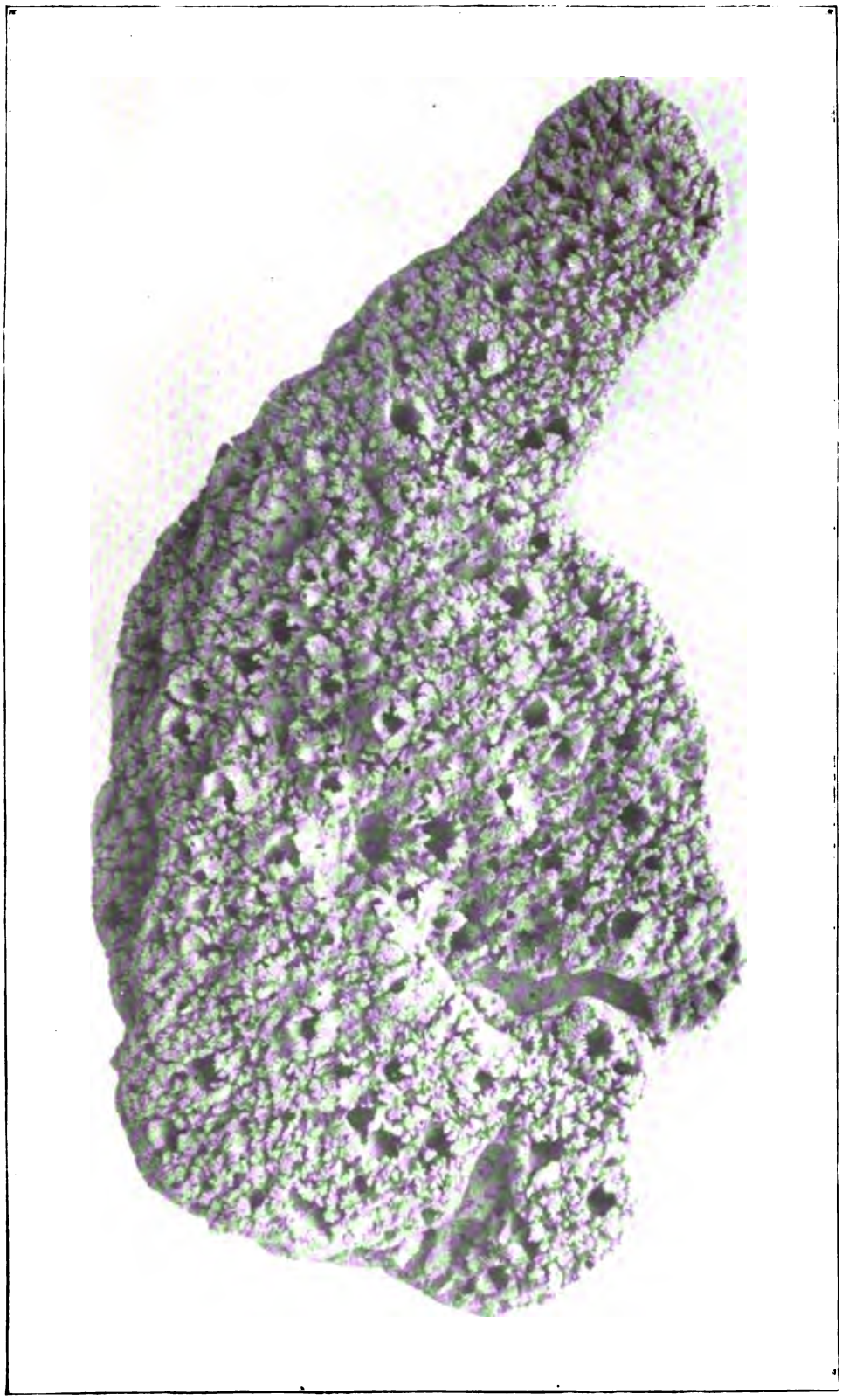
YELLOW SPONGE.

From Matecumbe Key. Height, 10 inches; greatest width, 9¼ inches; weight (dry), 4¼ ounces.



YELLOW SPONGE.

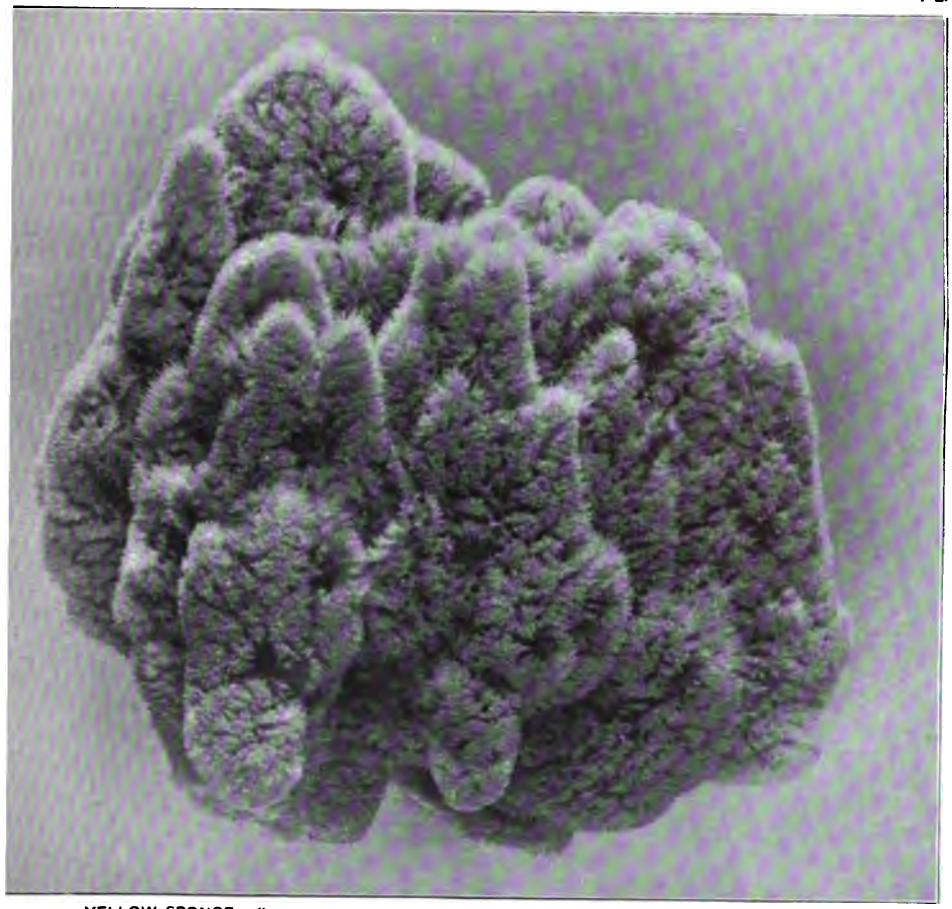
From Matecumbe Key. Width, 13¼ inches; height, 10 inches; weight (dry), 7¼ ounces.



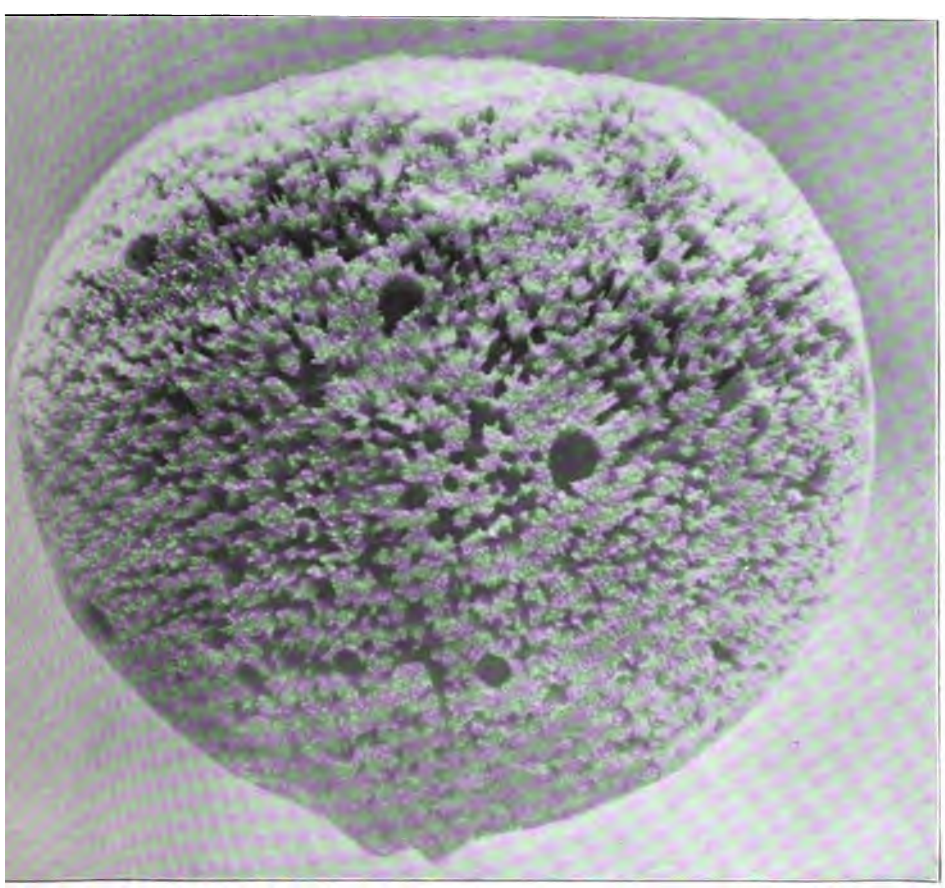
YELLOW SPONGE.

From Florida Keys. Length, 27 inches; weight (dry), 16 ounces.

PLATE 22.

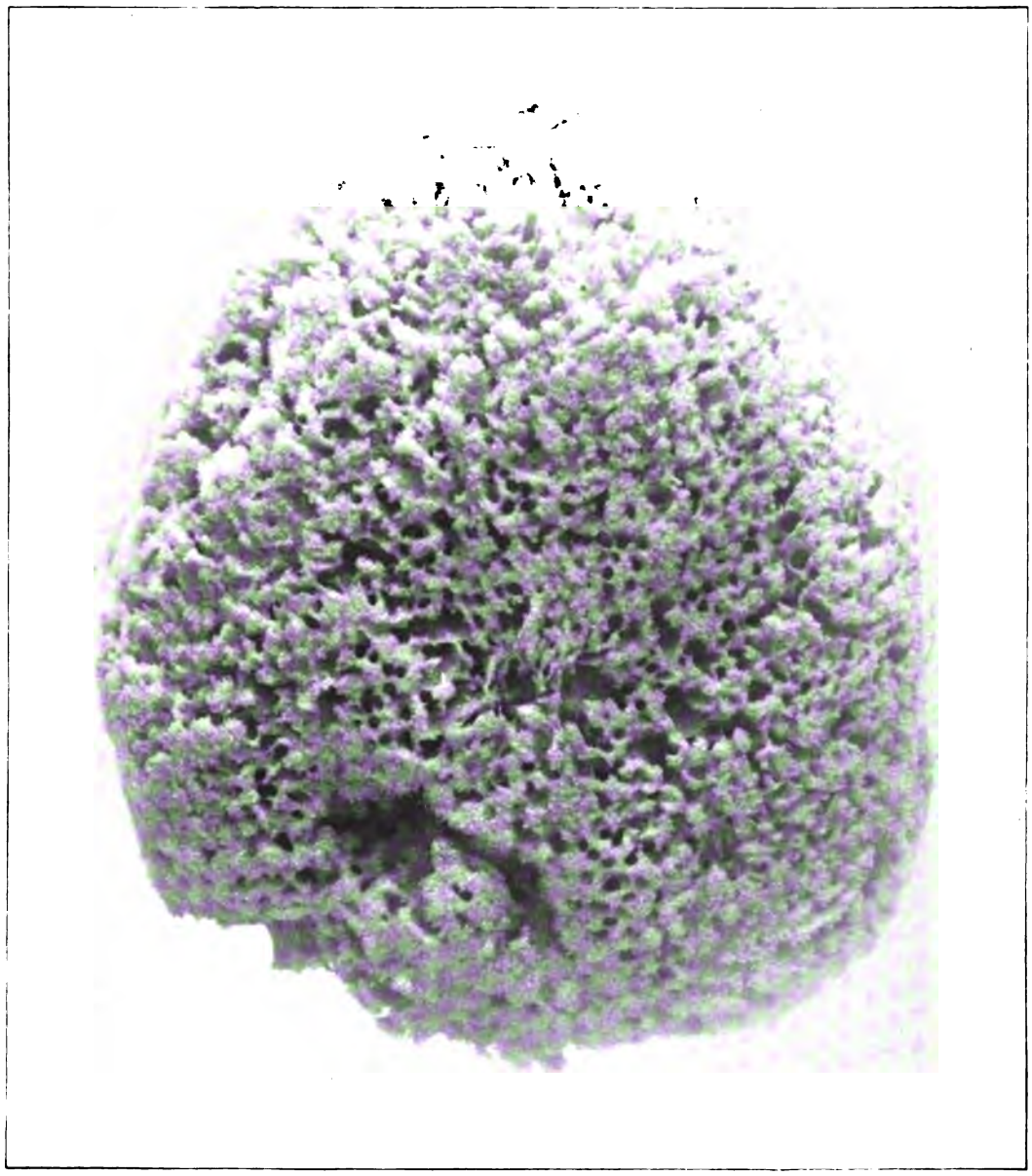


YELLOW SPONGE. (Locally called "Hardhead.") From Florida Keys. Diameter, 5½ inches.



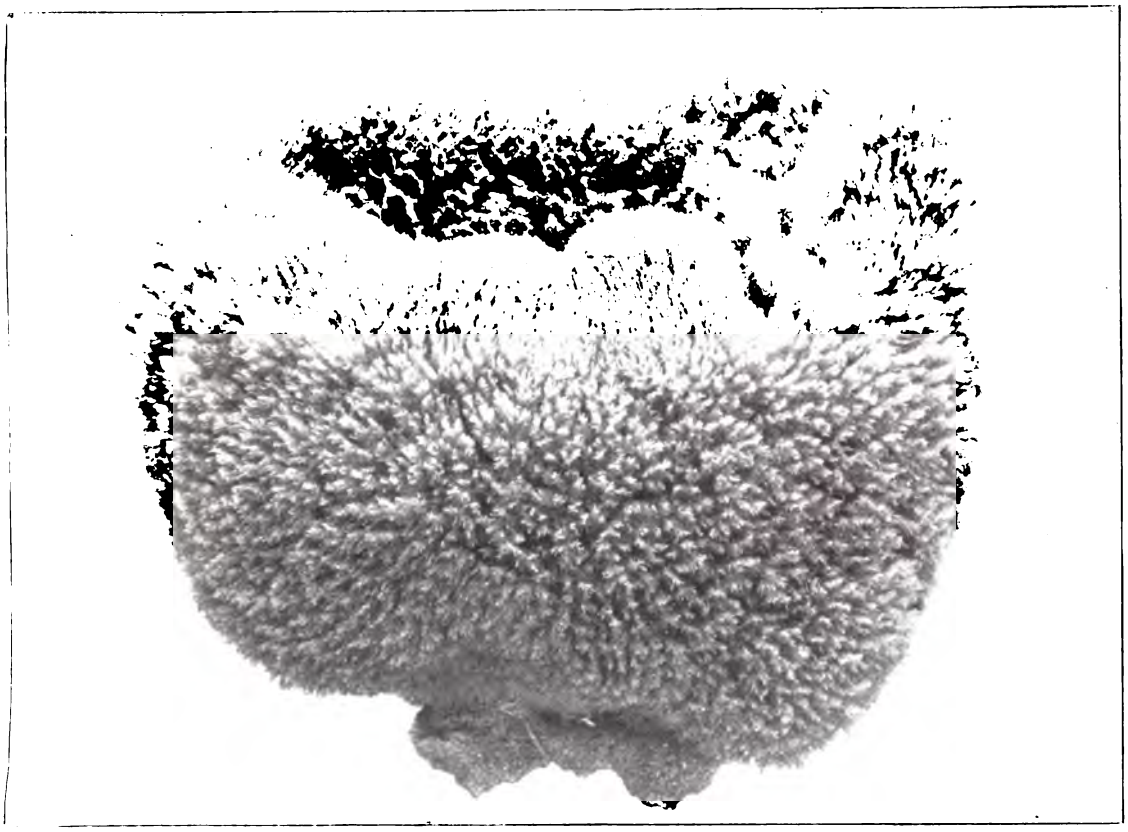
YELLOW SPONGE. From Biscayne Bay. Diameter, 8 inches; weight, 3 ounces.

his form is known as a "roller," or "rolling John," having been detached from the bottom and moved about by the currents.

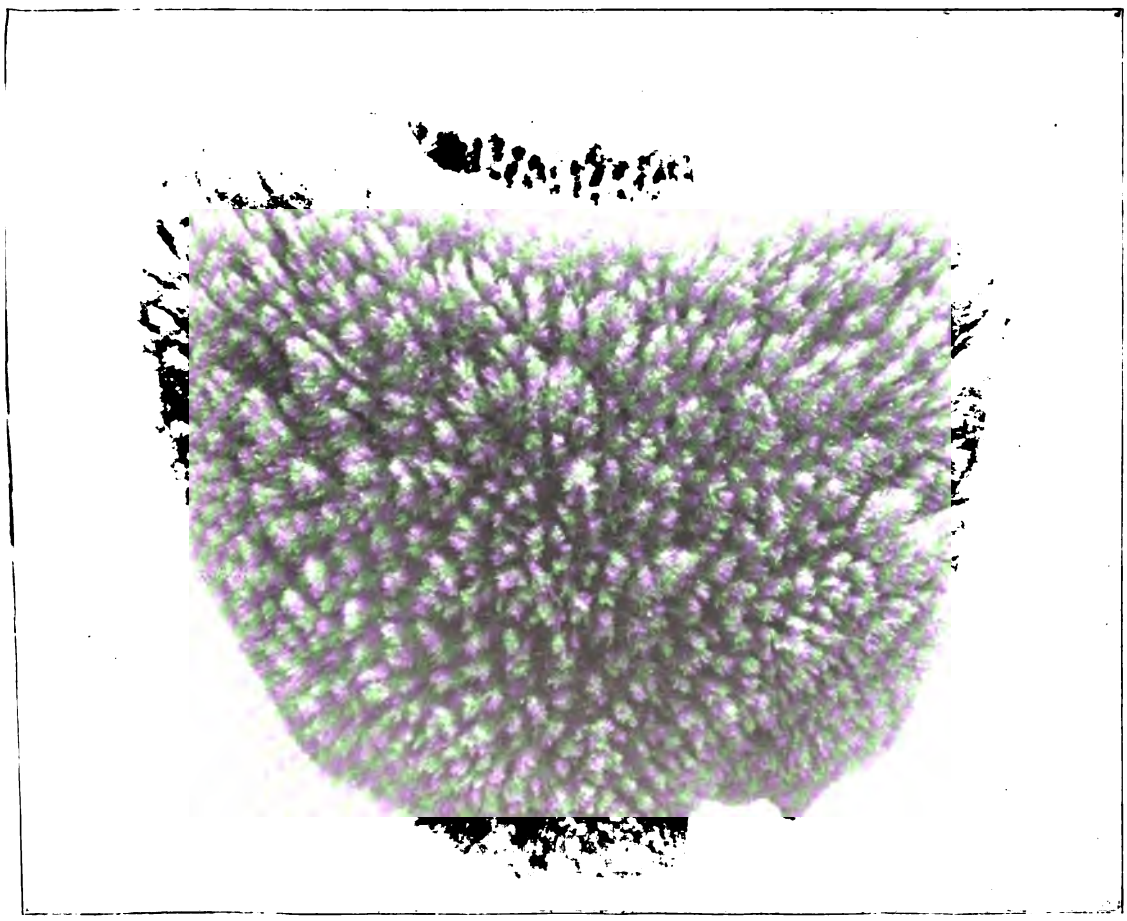


YELLOW SPONGE.

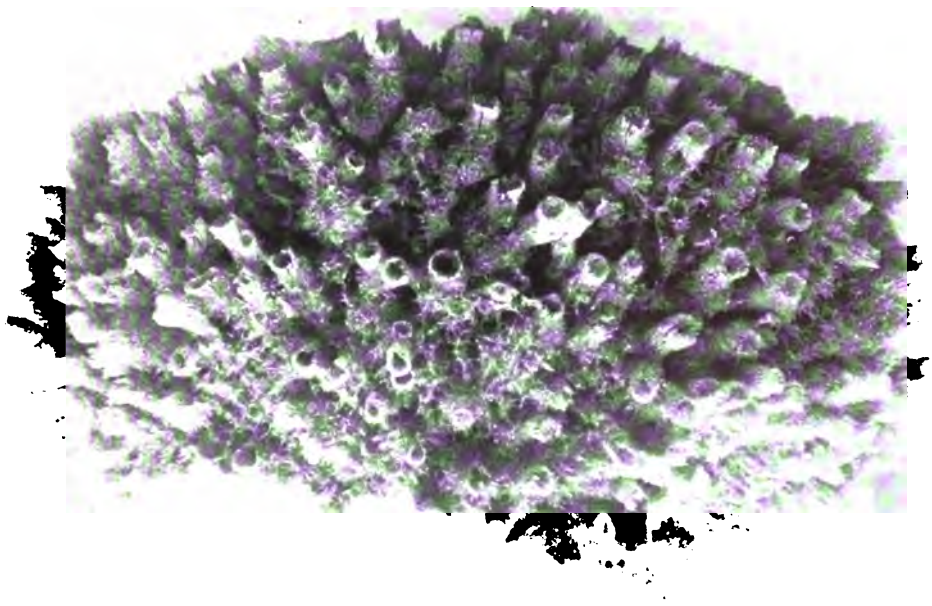
From Anclote Keys. Height, 11 inches; weight (dry), 4¼ ounces.



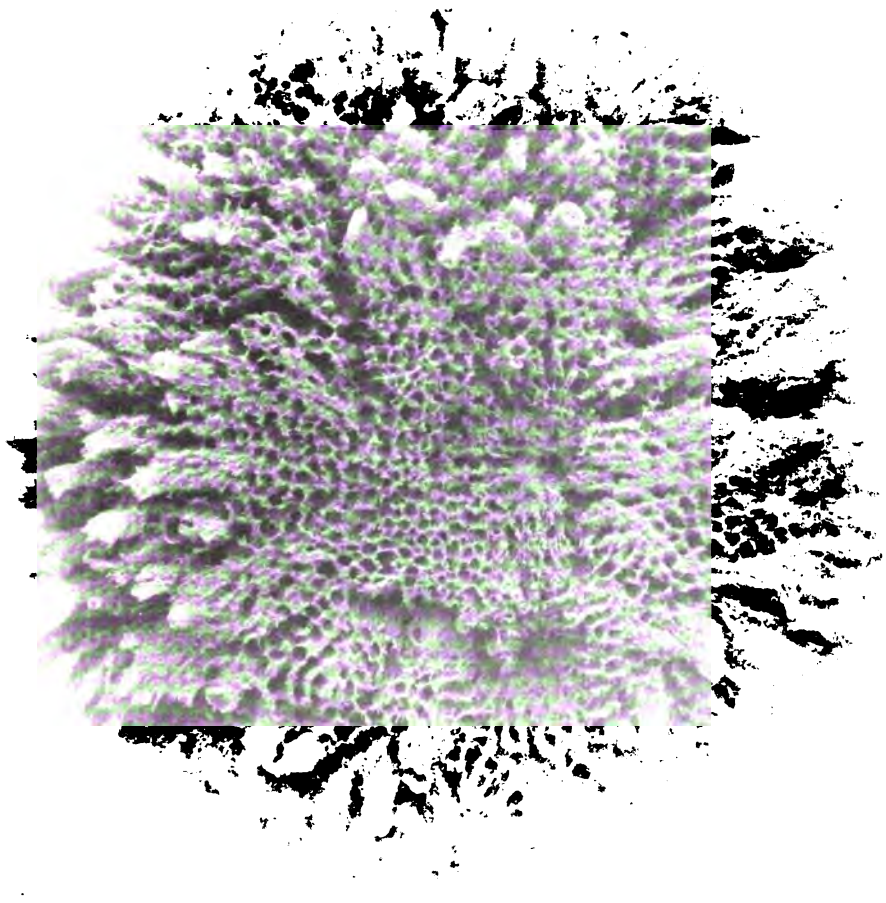
GRASS SPONGE. From Matecumbe Key. Diameter, 9¼ inches.



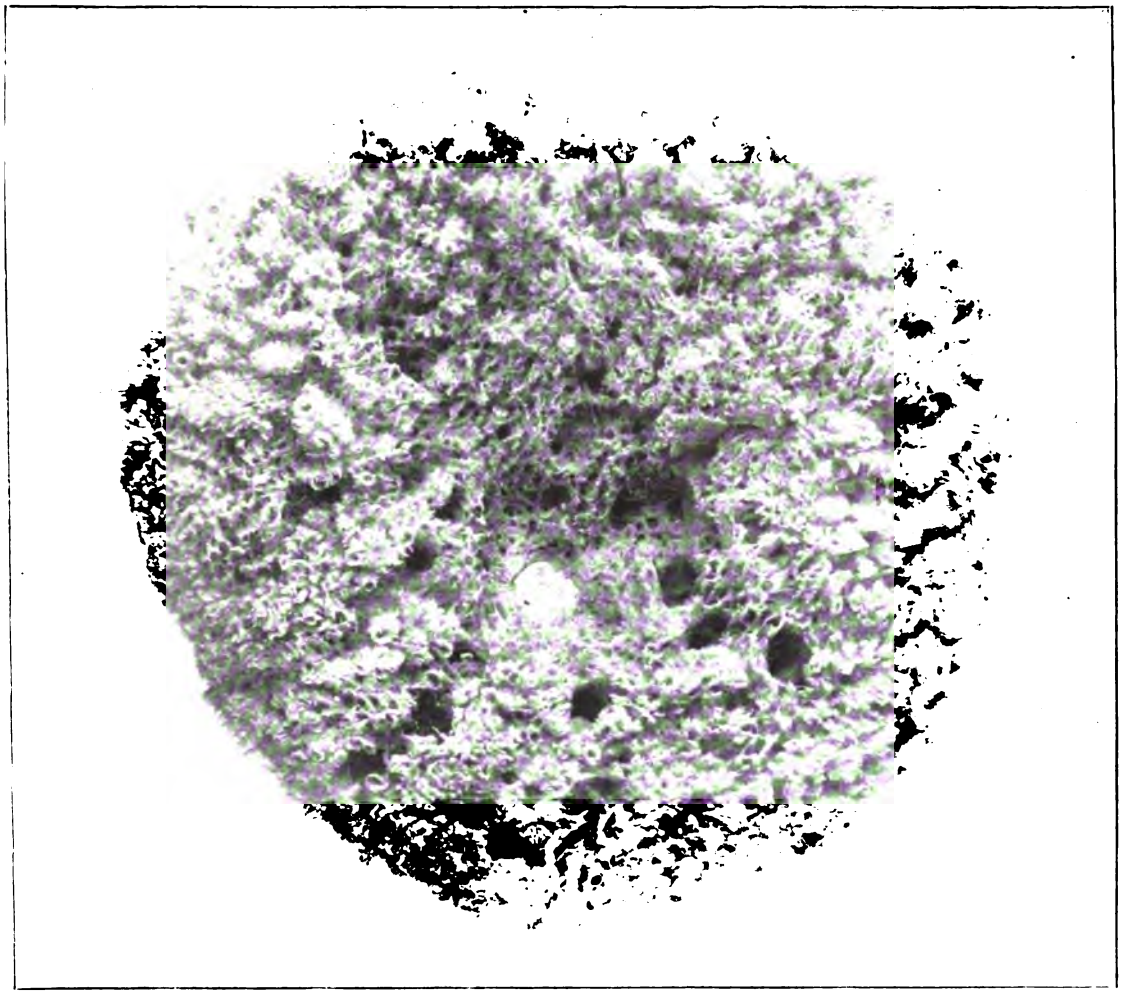
GRASS SPONGE. From Matecumbe Key. Diameter across top, 7½ inches.



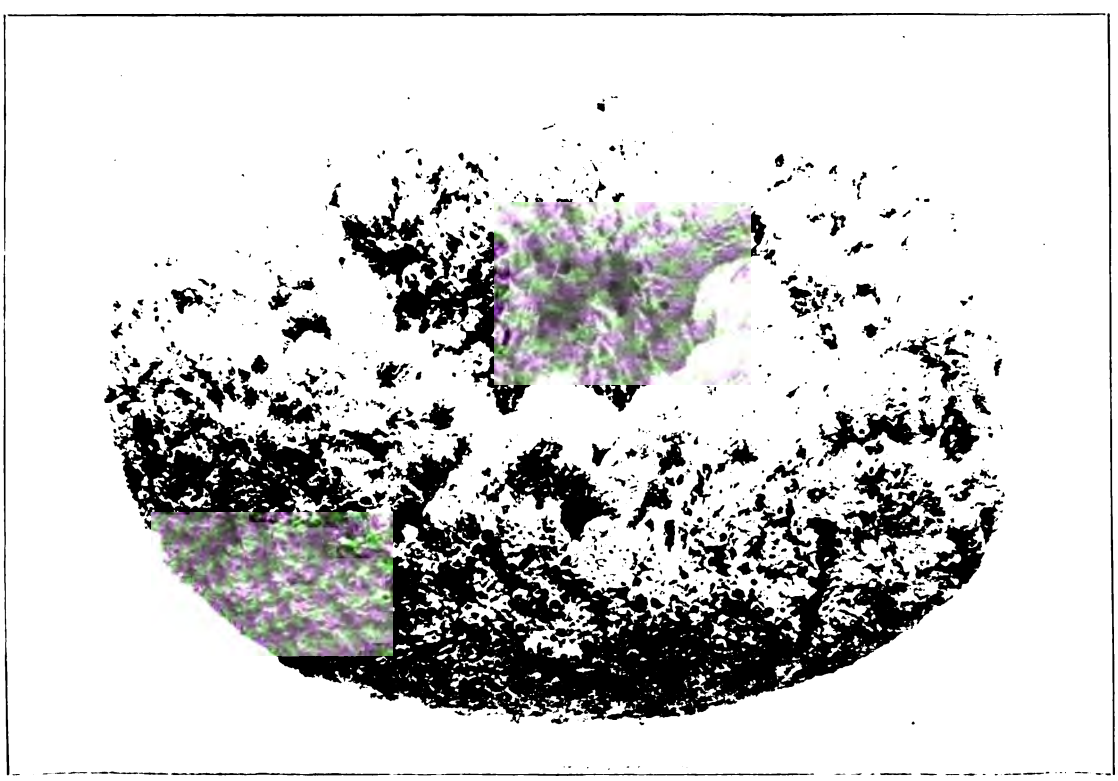
GRASS SPONGE. From Florida Keys. Side view. Diameter, 8½ inches.



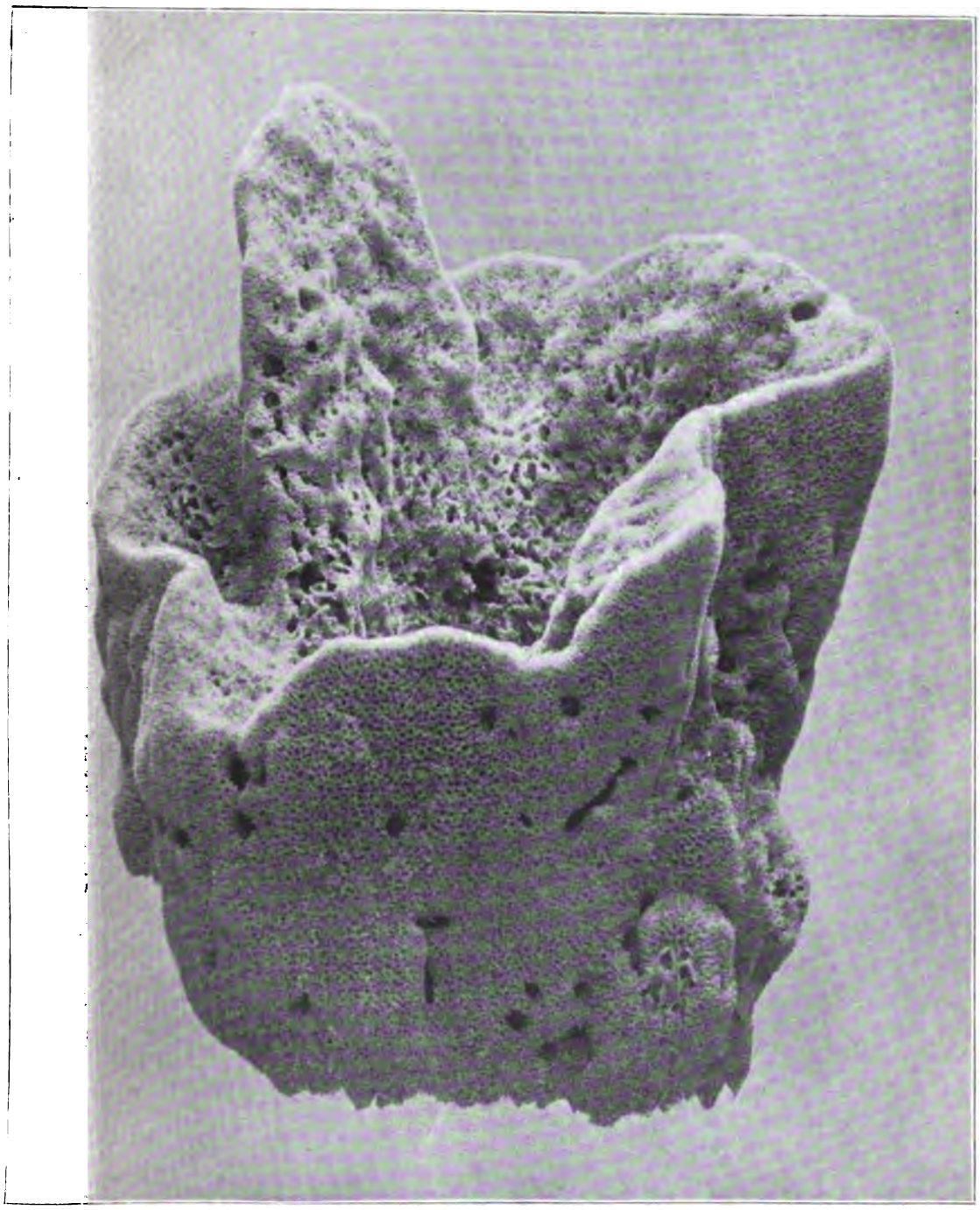
GRASS SPONGE. Same as above. Top view.



GRASS SPONGE. (Locally known as "Niggerhead.") From Matecumbe Key. Top view. Width, 14 inches.

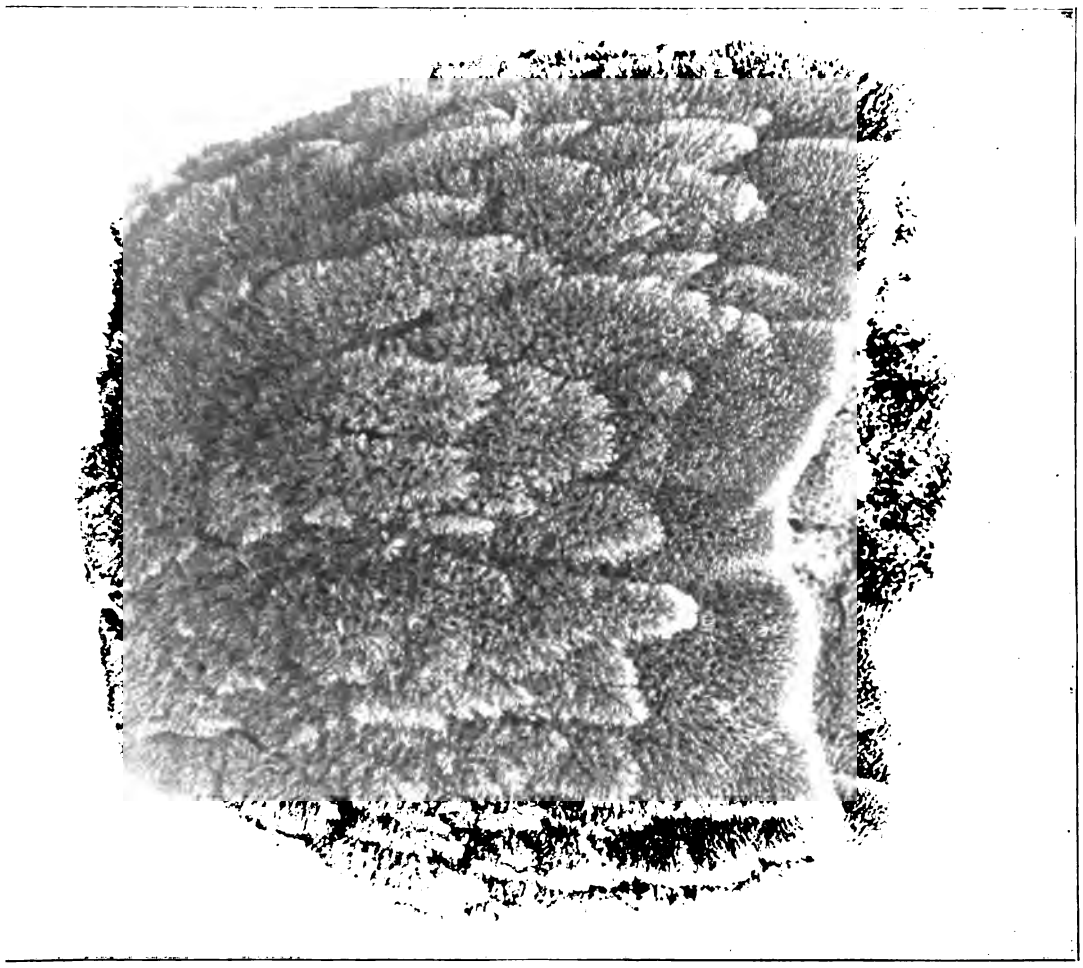


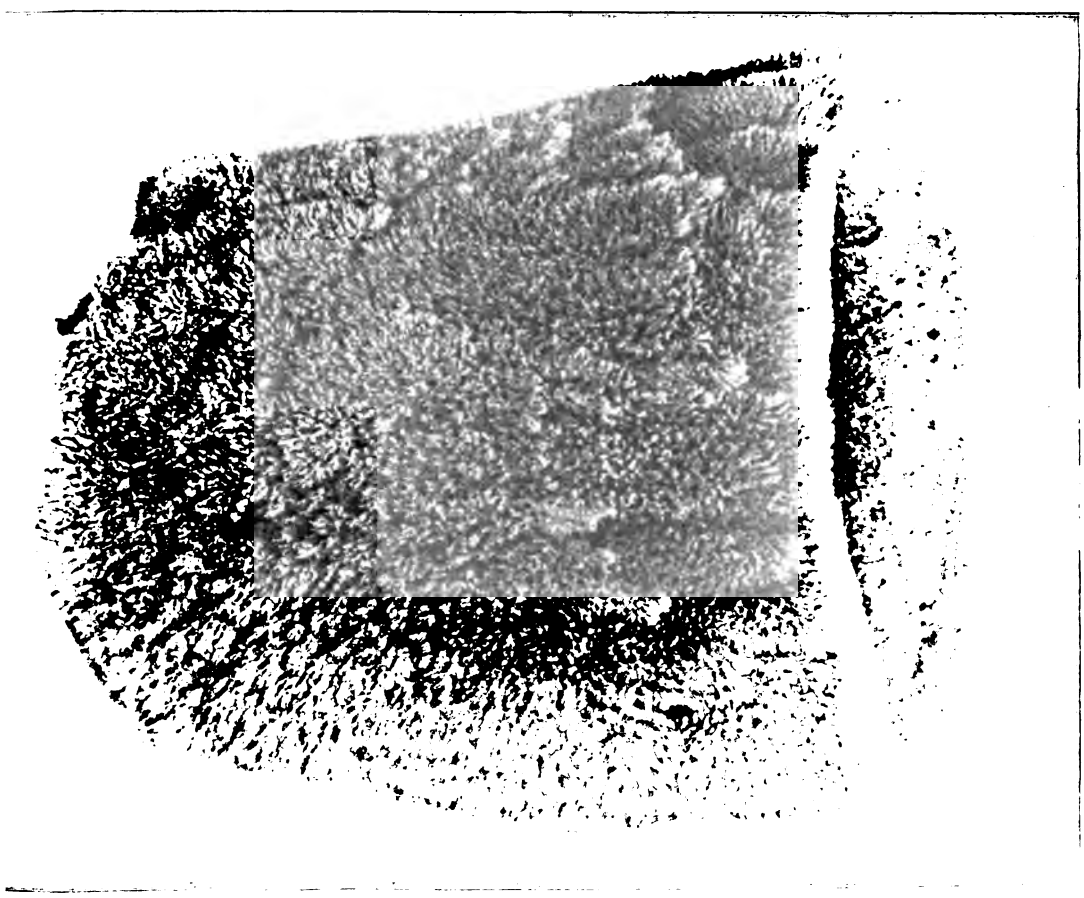
GRASS SPONGE. Same as above, viewed from side

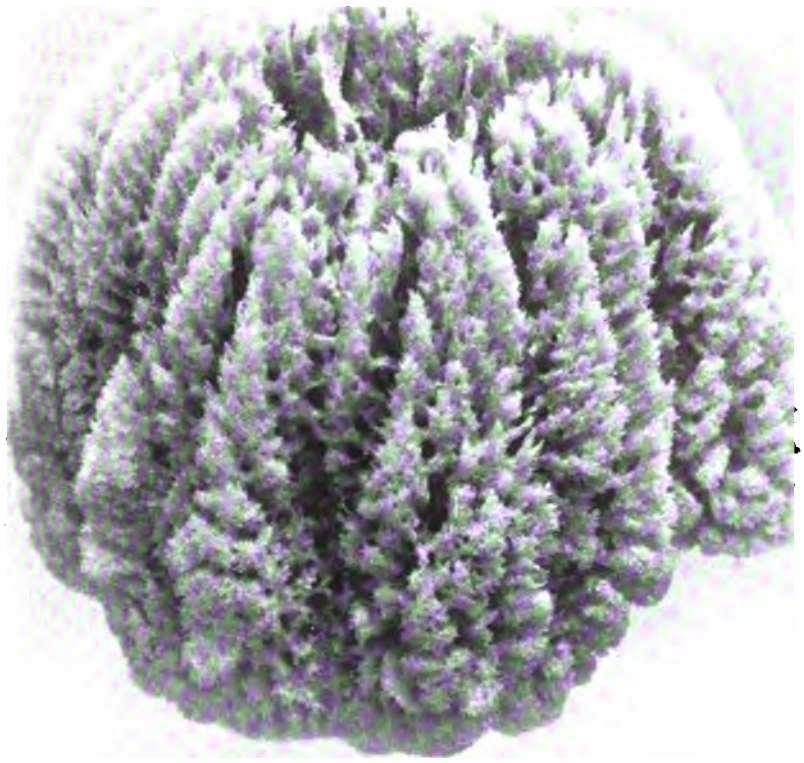


GRASS SPONGE.

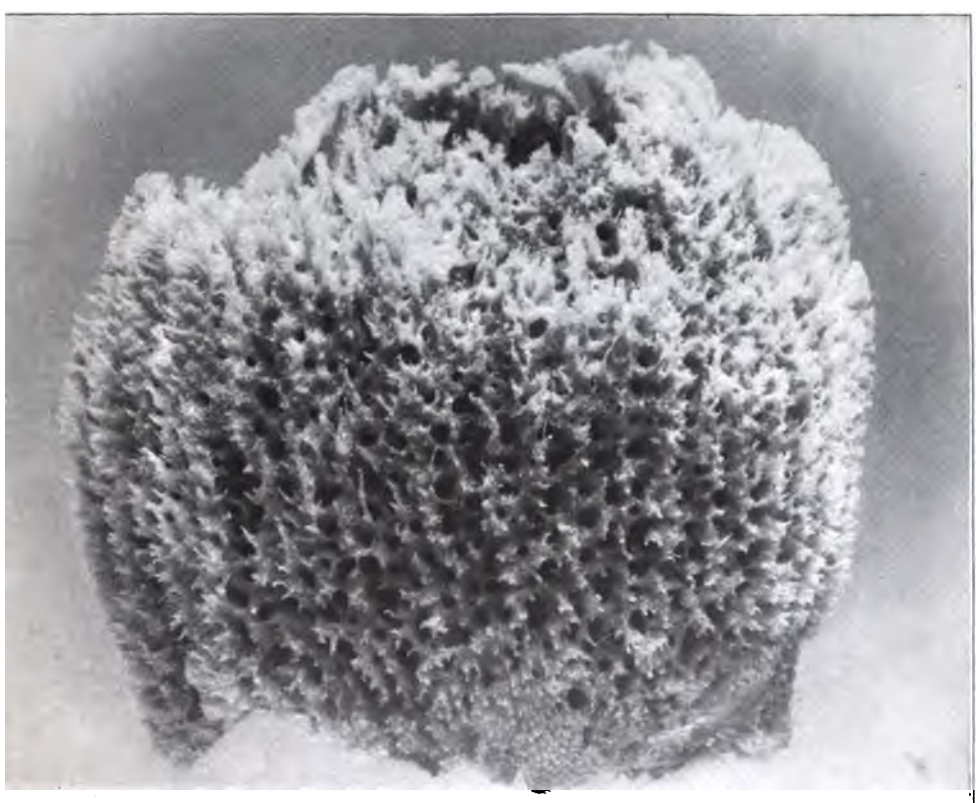
From Anclote Keys. Height, 13½ inches; diameter, 12 inches







GLOVE SPONGE. From Florida Keys. Diameter, 7 inches



GLOVE SPONGE. From Florida Keys. Greatest diameter, 6½ inches

GLOVE SPONGE.

From Florida Keys. Diameter, 8 inches.

# ON THE FEASIBILITY OF RAISING SPONGES FROM THE EGG.

By H. V. WILSON, Ph. D.,
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For the purposes of scientific investigation the problem suggested in the title of this paper presents no difficulties to the zoologist. Whether on the other hand it is practicable or even desirable to rear sponges from the egg for the purposes of the sponge-grower, is a question which can only be decided by experiments carried on continuously for some years. From the standpoint of the scientific breeder such experiments seem eminently desirable, and the probability that they would result in economic discoveries of importance is very great. It is my purpose to point out toward the end of this paper some of the advantages attainable, as I believe, by this method of breeding. I shall preface my remarks on the rearing of sponges with a brief account of the manner in which the egg development goes on.

Some sponges are known to be hermaphrodite, others have been described as of separate sexes. The probability is that sponges are in general hermaphrodite, but that the individual at one period produces chiefly male elements, and later chiefly female elements. Fertilization takes place in the body of the mother and the egg here undergoes its early development. The embryo eventually bursts the maternal tissue, and, passing into one of the canals, is caught by the current sweeping through the canal system and is discharged into the surrounding water through one of the large apertures (oscula) on the surface of the sponge.

In the great majority of sponges (horny and silicious forms) the embryo, or larva as it now should properly be called, since it leads a free life, is an oval, solid body, covered with slender hair-like processes of protoplasm, the so-called cilia. The cilia strike rhythmically to and fro, like so many minute and flexible paddles, and the sponge larva is by their means whorled through the water. Sponge larvæ, of course, vary in size, but frequently have a length in the neighborhood of 1 mm. ($\frac{1}{25}$ inch). The surface layer contains more or less pigment. Thus, in the commercial sponge, *Euspongia*, the larva is whitish, with a brown spot at one end. In *Tedania brucei*, a large red sponge, growing especially on the mangroves in parts of the Bahamas, the larva is a beautiful red.

The free-swimming life of the sponge larva is short, lasting, when bred in the laboratory, only a day or two. During this period the larva is moved along not only by its own relatively feeble motion, but, being subject to the action of currents, it may be carried a considerable distance from the spot where it was born. It eventually settles down on some firm basis and transforms. The cilia are lost, and the oval body flattens out into a disk so thin that it has the appearance of a minute incrusta-

tion. The circular outline of the disk is soon lost, the little sponge spreading in an irregular fashion over the surface to which it is now firmly attached. In two or three days the metamorphosis is complete, and we have a sponge, very small, to be sure, and without reproductive elements, but like the adult in fundamental structure. Its surface is perforated by minute apertures, the pores, through which water enters the body, and by a few larger apertures, the oscula, through which the water leaves the body. Ramifying through the interior is a system of spaces or canals which connect the pores with the oscula. Portions of this canal system form small spheroidal chambers, the walls of which are studded with cilia. It is owing to the motion of these internal unseen cilia that a current of water is constantly circulating through the sponge body, carrying to its tissues the oxygen and food (minute particles of animal and vegetable organisms) necessary for their life.

How long it takes for a sponge developed in this way to reach adult size and begin breeding is unknown. I have kept young sponges that have transformed and attached to the walls of my laboratory aquaria for days and weeks. After the first few days the increase in size has generally been imperceptible. But the unfavorable conditions incidental to such an unnatural habitat were doubtless responsible for this lack of success.

## PRACTICAL SUGGESTIONS ON REARING SPONGES.

More species of sponges breed during the warm season than at other times. Yet in the Mediterranean (Naples) some sponges are found breeding at all times of the year. In the Bahama Islands and on our own coast, I have found the breeding time of many sponges to fall within the period from midsummer on through early autumn. For the inauguration of experiments I should recommend the months of July, August, and September.

It is easy to determine when one of the horny or silicious sponges is breeding. On cutting out a piece of the sponge, the developing eggs scattered through the tissues can be seen without the help of a lens. They are minute, rounded bodies, often very numerous, and sufficiently conspicuous to catch an observant eye.

The means employed for getting young sponges must always be different from those made use of in the case of animals like fish, oysters, etc., in which artificial fertilization is practicable. Since the sponge egg is fertilized and undergoes its early development in the body of the mother, artificial fertilization is here of course out of the question.

The young in numbers ample for study can, however, be obtained in the following easy manner. The sponge being raised to near the surface of the water is then dipped up in a glass aquarium or bucket, in such a way as not to expose the animal to the air. In a few minutes time the ciliated larvæ will begin to be discharged. In the study of some Bahama sponges I found it convenient to take to the sponge-grounds, in a boat, a couple of good-sized tubs. In one of these some sponges would be placed for about half an hour. At the end of that time they were transferred to the second tub. The water of the first tub was meanwhile examined for the sponge larvæ. In this I was aided by negro boys, who soon became expert. We bailed out the water in 2-gallon glass vessels in which the little larvæ could readily be seen. The latter were then picked out with glass tubes and placed in a special dish. By the time the examination of the first tub was completed, the second would be found to

contain numbers of larvæ. These were collected in the same way, the sponges being thrown overboard.

It would seem in the case of sponges, as in so many marine animals, that the stimuli arising from confinement in a limited volume of water lead to the rather sudden discharge of those embryos (or in certain forms, eggs) that have reached the proper stage for birth.

I have no doubt that if the sponge were handled carefully, it would be possible to get from the same individual, day after day during the breeding season, numbers of larvæ, precisely as several batches of eggs are got from one codfish, for example.

The swimming larvæ thus obtained may be made to attach, during the next day or two, to the walls of the dishes in which they are kept, or to pieces of wood or small stones. After attachment the young, or, as we might say, the sponge "spat," are easy to handle. In this connection, however, it will be well to bear in mind that the circulating pipe water of aquaria, even large and elaborate ones such as those at Naples and Woods Hole, has been found to be unsatisfactory for the rearing of young sponges, as indeed it is for the young stages of many marine organisms. The sponges become covered with sediment, and bacteria develop. Changing the water in the dishes twice a day is, on the whole, a better method. But this is far from an ideal environment. It will probably be much better, after the attachment of the spat to pieces of wood, shells, etc., at once to transfer the latter to some natural site known to be adapted to the growth of sponges.

I hardly think that the method of getting young sponges which I have just described can ever be adapted to the needs of the sponge-grower. And yet, for the purposes of experiment, where a few hundreds or a thousand young sponges would suffice, the method is adequate. I believe, however, that live-boxes may be devised in which the sponge may be kept imprisoned in its natural home, though at some convenient depth, and in which the discharge of larvæ may go on normally day after day. Such a box must have fine metal gauze windows on the sides and above, through which the water may pass freely, and yet with meshes sufficiently fine at any rate to hinder the passage of the larvæ through them. Projecting shelves, which must be easily removable, might be arranged one above the other. The sides and bottom of the box should, moreover, be covered with removable pieces—tiles, for instance. The larvæ settling down on the removable shelves or other pieces would attach to them, and might from time to time be taken out with as much ease as the honey stored up in the modern manufactured comb is removed from the hive.

The precise form of live-box to be used will naturally only be determined after proper experiments. To prevent as far as possible the settling of the larvæ on the body of the mother, a phenomenon very apt to occur, it will perhaps be found well to place the adult on a perforated tray near the top of the box, and a series of such trays, one above the other, may be found a good device. In planning experimental boxes of this sort, the character of the motion of the sponge larva should be borne in mind. The larva not only swims, frequently making long, shallow dives, but also creeps about over the sides and bottom of the vessel in which it is kept.

The live-box has proved itself of great use to the naturalist desirous of obtaining the young stages of animals, which are difficult to keep or breed in the laboratory. In this connection I well remember the experiences of a companion (Prof. C. L. Edwards), engaged in the study of the development of the large holothurian or sea-cucumber

(Mülleria), so common in parts of the Bahama Islands. It was with the greatest difficulty that a few embryos of this form could be got in the laboratory. When, however, the animals were confined in a large box anchored in about a fathom of water, quantities of developing eggs could be had by drawing up with a tube some of the sediment in the bottom of the box.

The "spat" once obtained in abundance, success will next depend largely on the selection of the locality in which the young sponges are to be set out. A careful study of the Florida grounds should be undertaken, with the view of investigating, among other points, this very matter of the kinds of locality best adapted to the growth of the various grades of sponges. Quiet water, a firm bottom, and an absence of muddy sediment seem essential desiderata. The question of enemies is probably of minor importance, and yet the well-known student of sponges, Vosmaer, mentions that he has several times seen the European hermit-crab (*Pagurus*) greedily eat a common silicious sponge (*Suberites*), certainly quite as unappetizing a morsel as the coarsest commercial sponge.

When it has once been accurately determined what are the physicial and biological characteristics of the Florida grounds, which produce the finest sponges—and it may be mentioned here that sponges are among the most variable of animals and seem to be peculiarly affected by their surroundings—a detailed comparison should be made between these grounds and those parts of the Mediterranean producing the finest grades. The purpose of such a comparison would be to discover whether we really lack any of the natural advantages necessary for the production of the finest sponges and, if so, whether these can be artificially reproduced—whether, for instance, it would be possible or desirable to imitate on this side a particular kind of bottom found in the Mediterranean.

Following on the investigation of the sponge-grounds, I believe it to be eminently desirable to start a series of experiments, the purpose of which shall be to discover how far, along what lines, and by what means sponges may be artificially altered by breeding. The great variability of sponges in nature leads one to believe that they would quickly respond as individuals to a change in the environment, and thus, simply by growing the animals in a superior locality, an improved variety, constant, as long as the sponges continue to grow in that locality, might be produced. It is quite likely that such improvements could be carried out on sponges propagated by cuttings as well as on those grown from eggs. In improving races, however, it has always been found that the two important means are sexual breeding from selected specimens and grafting, the latter method being commonly regarded as only applicable to plants.

In sponges, as in other organisms, increase of knowledge will in all probability confirm the belief, already fairly well grounded, that individuals developed from the fertilized eggs vary more, i. e., exhibit more differences one from the other, than individuals grown from buds or cuttings. Herein, to my mind, lies the advisability of growing sponges from eggs as well as from cuttings. The latter method, being quick, sure, and simple, can at once be made of great practical use. Breeding from the egg is more complex, and must be carefully tried by competent experimenters. In the end, however, I believe that it will lead to great improvements in the quality of our sponges.

I would suggest that, after selection of a proper locality, a small plantation of sponges developed from eggs be started and carefully watched. As the sponges grow, it would be a simple matter to pick out those individuals in which the fiber varied in

the desired direction. A small piece cut out would not seriously injure the sponge and would show the quality of fiber as well as the entire body. Selected individuals might be removed from the general ground and during the breeding season placed together in large live boxes. The "spat" collected from such individuals would doubtless develop into superior sponges. I do not know any marine animals which would seem to be so adapted to continuous rearing, with constant improvement of breed, as sponges. Their plant-like habit of growth makes it easy to handle and experiment upon them. Their variability, especially in the matter of the skeleton, would seem to insure success to selective breeding; and the very simplicity of what is desired, namely, improvement in the quality of the skeletal fiber, would at once lend a directness to the efforts of the cultivator, which should lead to comparatively early results.

In closing, I may direct your attention to a method of race improvement, so far practiced only in the cultivation of plants, but to which the vegetative character of sponges will readily lend itself. I refer to the method of grafting. The ease with which two or more individuals of the same species of sponge, irrespective of age, may be made to fuse, and become henceforth a single individual, is well known. Dr. Grant records observations on this head as far back as 1826. Among later experimenters I will only mention Vosmaer. This fusion of individuals goes on commonly in nature. An interesting account of a number of cases may be read in Johnston's British Sponges and Corallines, published 1842, page 11.

The natural tendency of sponges to grow together, coupled with the ease with which they may be propagated by cuttings, would make artificial grafting in these animals a simple matter. With a small plantation of very superior sponges at hand, the result of careful breeding from selected individuals, and other plantations consisting of sponges grown from cuttings, grafting ought to be not only a scientific but an economic success. At slight expense, large numbers of common sponges might be improved simply by pinning to the common cutting a piece of the improved variety.

CHAPEL HILL, NORTH CAROLINA.

# THE HUDSON RIVER AS A SALMON STREAM.

By A. NELSON CHENEY,

*State Fish-Culturist, New York Fisheries, Game, and Forest Commission.*

During the past twenty-five years to my personal knowledge, and probably for a ɔnger period, there have appeared in various publications, from time to time, articles escribing the Hudson River as an original salmon stream. Some have merely made he broad statement that the river once contained *Salmo salar*, and others in more xplicit language have described the great quantities of salmon that once inhabited he stream, and deplored the fact that they had become extinct in the river. Almost ithout exception the sole foundation for the statement that the Hudson was once a atural salmon river rests upon an extract from the log of Henry Hudson, of the *alfmoon*, who records that in 1609 he saw a "great store of salmons in the river" hich now bears his name.

Within the past fifteen years a gentleman wrote to a newspaper published in a ty on the bank of the Hudson declaring that his grandfather formerly caught large ımbers of salmon in the Hudson, and for this reason it was a proper water to be ɜstocked with the king of fresh-water fishes.

That old, old story, which originated in England or Scotland one or two hundred ɛars ago, that apprentices and servants provided, when indentured to their masters, ıat they should not be required to eat salmon oftener than twice a week, has been ansplanted to the banks of the Connecticut and has even been applied to the udson and its alleged salmon.

Nevertheless I maintain, and will show in this paper—as I believe, conclusively—ıat the Hudson was not originally a salmon stream, and that no salmon were ever ɔund in it except possibly an estray from the Connecticut, until planted by the United tates Fish Commission and the Fisheries Commission of the State of New York.

As to Hudson's declaration, or to be exact the declaration of Robert Juet, the ıaster's mate of the *Halfmoon*, for he it was who wrote the journal—under date of eptember 3, 1609, he writes: "So wee weighed and went in and rode in five fathoms, ɛe ground, and saw many Salmons, and Mullets and Rays very great. The hight is ) degrees 30 minutes."

Under date of the 15th: "Wee ran up into the river, twentie leagues, passing by igh mountains. Wee had a very good depth as thirteene fathoms, and great store f salmons in the river." A boat was sent out and with a net "ten great mullets of a ɔot and a half long apiece, and a ray as great as four men could hale into the ship" ɾere taken.

Not a single salmon was captured at any time while the ship was in the river. The *Halfmoon* entered the mouth of the river September 3 and anchored inside Sandy Hook, and the next day, the 4th, the fishing was done. The ship ascended to the present site of the city of Hudson, and a boat's crew was sent up the stream to about where Waterford now stands, or a little north of the present city of Albany. The ship and its master returned and set sail for Europe on the 23d of September, so that all told Hudson was in the river twenty days in the month of September. Had there been salmon in the river he must have seen them between Sandy Hook and Waterford, and they would not have been in that portion of the river at that time, as their spawning habits would have taken them 50 miles farther up the river than Waterford, to Bakers Falls, to which point shad ran until stopped by the building of the Troy dam in 1825.

In some of the Canadian rivers there is a late run of salmon, the fish running as late as October, but this was not true of the Connecticut or of other New England salmon streams, nor has it proven true of the Hudson since it was stocked by artificial means. Hudson being an Englishman, and possibly more or less familiar with salmon in the rivers of his own country, and Juet being born at Limehouse, on the river Thames, where salmon were then common, it is perhaps fair to assume that seeing schools of large fish of some sort, one or the other associated them with the fish of his home waters and called them salmon in the log.

In a description of New Netherland, printed in Amsterdam, Holland, in 1671, occurs this sentence: "The streams and lakes, rich with fishes, furnish sturgeon, salmon, carp, bass, pike, roach, bleak, all sorts of eel, sunfish which resemble the bullhead in taste, and codfish which are caught near waterfalls." It will be observed that European common names are applied to the fishes, and doubtless the writer was familiar with the fishes of the old country and applied their names to the fishes in the new country that to him resembled those of the old. To this day codfish are not caught near waterfalls, and it is more than doubtful if salmon existed in the lakes and streams any more than bleak and roach.

New Netherland is bounded "on the south by Virginia, northeast by New England, north washed by the river Canada, and on the coast by the ocean." Besides codfish at the waterfalls and salmon in the streams and lakes, the writer found that "New Netherland hath, moreover, a wonderful little bird scarcely an inch long, quite brilliant in plumage, and sucking flowers like the bee; it is so delicate that a dash of water instantly kills it. When dried it is preserved as a curiosity." The hummingbird is a little larger now and more hardy, but the description is perhaps as accurate as the statement that codfish are taken at waterfalls and salmon in lakes within the boundaries as given of New Netherland.

In 1680 Jasper Danker and Peter Sluyter, members of the society of Labadists in Holland, visited this country, and they record of the Mohawk, a tributary of the Hudson: "There are no fish in it, except trout, sunfish and other kinds peculiar to rivers, because the Cahoos stop the ascent of others." They dined in state "with Madam Rensselaer, at Albany, and had to eat exceedingly good pike, perch and other fish," but no salmon.

New York had salmon streams on the north, flowing into the St. Lawrence, Lake Champlain, and Lake Ontario, for I have found laws for their protection enacted in 1801 and later, and mentioning the Oswego, Grass, Racket, St. Regis rivers, and Fish

and Wood creeks, as well as other streams. A law enacted in 1801 provided that no dams should be erected on streams flowing into Lakes Ontario, Erie, or Champlain to prevent salmon from following their usual course up said streams, and when dams were erected they should be provided with what are now called fishways, to enable the fish to pass over the obstruction. There is every indication that the lawmakers of the last of the last century and the first of this understood fully the value of the fish in the waters of the State as food and threw every possible safeguard around them, but there is no record of a law protecting salmon in the Hudson until 1771, when it was enacted:

> Whereas it is thought that [if] the fish called salmon, which are very plenty in some of the rivers and lakes in this and the neighboring colonies, were brought into Hudson's River, they would, by spawning there, soon become numerous, to the great advantage of the public.
>
> And whereas a number of persons in the county of Albany propose to make the experiment and defray the expense attending the same: In order that the good design may be more effectually carried into execution, it is conceived necessary that a law should be passed for prohibiting the taking and destroying the fish for a term of years.

This act was signed by John, Earl of Dunmore, and in less than a month after, viz, April 2, 1771, the common council of Albany passed the following resolution: "Resolved by this board, that a letter be sent to William Penturp for to come down and agree with the corporation, if he can undertake to bring live salmons into Hudson's River." There is no record, however, that anything was actually done under this resolution to stock the Hudson with salmon.

Samuel Latham Mitchill, professor of natural history in Columbia College, New York, wrote in the Transactions of the Literary and Philosophical Society of New York, in 1815: "There is no steady migration of salmon to this river. Though pains have been taken to cherish the breed, salmon has never frequented the Hudson in any other manner than as a stray."

In 1857 Robert L. Pell, of Pelham, Ulster County, petitioned the legislature to construct fishways in the Hudson, and offered to stock the river with salmon without expense to the State. There is no evidence that the State accepted the proposal of Mr. Pell, and certainly the fishways were not built.

I believe it unnecessary to quote further from old records and laws to prove that the Hudson River was not originally a natural salmon stream. The evidence is chiefly of a negative character, but I am of the opinion that it is conclusive.

What has been done to make the Hudson a salmon stream has been done within the past twenty-five years, and I will rehearse the operations of the national and State fish commissions to this end as briefly as possible. Beginning with 1873, and continuing for three years after, the Fish Commission of New York planted in the tributaries of the Hudson a quantity of fry of the Pacific salmon, hatched from eggs furnished by the United States Fish Commission. Several hundred thousand fry were planted, but so far as known, after going to sea as smolts, not a single fish returned to the river, and this is true also of other plantings of this species of salmon in other Atlantic coast rivers.

In 1891 the late Col. Marshall McDonald, then United States Commissioner of Fisheries, requested me to make an examination of some tributaries of the Upper Hudson with a view to making a plant of yearling quinnat salmon. He was thoroughly convinced that the attempt to stock the Atlantic rivers with the fry of this fish was an abject failure, but at the Wytheville station of the Commission in

Virginia rainbow trout from California had been established in the hatchery stream by planting fingerling fish after plantings of fry of this species of fish had failed, and he desired to try a like experiment with the salmon also from the Pacific coast. I selected several streams in Vermont, tributary to the Battenkill River, which in turn flows into the Hudson. The streams were free from everything injurious to young salmon and there were no natural or artificial obstructions in them. Later, I went to Vermont with one of the United States Fish Commission cars and planted several thousand yearling (California) salmon in the streams selected for the purpose. Not one of them has ever been heard of since they went down to the sea.

The experiment of stocking the Hudson with Atlantic salmon (*Salmo salar*) was begun in 1882, at which time 225,000 fry were planted in small streams tributary to the head of the river about 260 miles above Sandy Hook. Nothing was heard from this plant until 1886, or four years after, when adult fish returned to the river weighing from 9 to 16 pounds, and ascended to Troy, where they were stopped by the State dam. Every year since, with one exception, plants of salmon fry or yearlings have been made in the river, and every year adult fish have been captured in the lower river by the nets of fishermen.

One thing has been proven to my satisfaction beyond peradventure by these experiments. The young of the *Salmo salar* when planted in the Hudson do not go to the sea until they are two years old, and they return from the sea when they are four years old. If I should make this statement before a European audience I would be accused of rank heresy, and possibly right here in Tampa delegates to the National Fisheries Congress will desire to know what proof I have of this assertion. I planted salmon fry in a trout stream tributary to the Hudson which had never contained salmon, and it was two years before they arrived at the smolt stage and took their departure for the sea in silvery livery. Selecting another stream I made a like plant, and it was two years before the parr put on the smolt dress and turning their tails to the sea drifted down with the current. During the past fourteen years I have planted *salar* fry in various streams, and always, when in a new stream where they could be watched that no mistake would be made, they have remained for two years before going to sea.

Since the first plant of *salar* fry a total of 3,486,000 have been planted in the Hudson River, this number including 12,000 yearlings. All the eggs were furnished by the United States Fish Commission and came from the Penobscot River in Maine. For a number of years after the initial plant the United States paid all the expenses of hatching and distributing the young fish, but later the Government furnished the eggs and the Fisheries, Game, and Forest Commission of New York hatched and planted the fish at the expense of the State.

It is of record that in one year over 300 adult salmon, from 10 to 38 pounds each, were taken in nets in the Lower Hudson, every fish taken contrary to law. It is true that some salmon taken in nets are released by the fisherman, but the high price offered for Hudson River salmon in the New York markets sorely tempts a fisherman to kill such salmon as may be taken in his net, instead of releasing them uninjured, as the law directs. Fishways have been erected in the Hudson by the State at Troy, Mechanicsville, and Thomsons Mills, but other fishways must be built before the river is open to the fish from the sea to the pure water of the upper river where the salmon would naturally go to find spawning-grounds. The Cohoes Falls on the Mohawk is

to-day as much of a bar to the upward migration of salmon as when Jasper Danker made the entry in his journal in 1680, which I have quoted. Baker Falls, on the main river, has been supposed to be one of the causes why salmon never frequented the river at the time they ran into the Connecticut. These falls stopped the shad and and it has been said that they would stop salmon. Possibly they would, but I visited the falls with the late Commissioner McDonald and we were both of the opinion that it was possible for salmon to surmount them on the proper stage of water.

Why the Hudson was not originally a salmon stream when the Connecticut, a neighboring river, was, I shall not attempt to explain. It may have been that Cohoes and other falls on the main river and its tributaries operated as a bar to keep them from their proper spawning-grounds, but one thing has been fully demonstrated: The Hudson River of to-day, with its sewage from towns and poisons from mills and factories, does not deter salmon from entering from the sea once the fry are planted in its headwaters, and with fishways in all the obstructions, natural and artificial, it could be made a self-sustaining salmon river if the netters would obey the law, while the State fisheries commission aided nature in keeping up the supply of young fish by artificially hatching the eggs. Colonel McDonald told me on more than one occasion that if the Hudson were open to salmon, and proper efforts were made to keep up the supply of young fish, and netting regulations were enforced, the river would from its salmon add $100,000 a year of profit to the State financially, while largely augmenting the food supply.

GLENS FALLS, NEW YORK.

# A PLEA FOR THE DEVELOPMENT AND PROTECTION OF FLORIDA FISH AND FISHERIES.

By JAMES A. HENSHALL, M. D.,
*Superintendent of United States Fish Commission Station, Bozeman, Monatna.*

The principal fishing industries of Florida are prosecuted on the Gulf coast, at Pensacola, Tampa, Punta Gorda, and Key West. The shad fishery of the St. Johns River is also very important, and considerable business in this direction is done at various places on the east coast. At Pensacola the principal fish product is the red snapper, a fish of good size and with firm flesh of fine quality, which bears transportation well. It is taken with hook and line on the snapper banks in from 10 to 50 fathoms and from 10 to 50 miles offshore. At Cedar Key, Tampa, and Punta Gorda the bay and brackish-water fishes are taken by haul seines on the shores of the bays and inlets; the varieties mostly handled are mullet, redfish, or "bass," as it is known commercially, sea trout, pompano (the best of all fishes for the table), Spanish mackerel, jackfish, etc. The mullet is, perhaps, the most important, as it is shipped fresh, on ice, while large quantities are cured by salt.

At Key West many of the fishes are entirely different from those of the other waters of the State, and belong rather to the West Indian fauna. They comprise the coral fishes, salt-water fishes par excellence. All are taken with hook and line, as the various seines and nets can not be utilized owing to the ragged coral formation of the shores and reefs. The principal fish are kingfish, mackerel, groupers, snappers, grunts, jewfish, etc., which exist in great variety. The catch is almost entirely consumed at Key West. Formerly a fleet of smacks carried live fish in wells to Havana until a prohibitory import duty was imposed by the captain-general upon fishermen from the United States, which compelled the abandonment of the industry and the sale of the smacks to Spanish fishermen, who, besides taking fish contrary to law in Florida waters, carry on a nefarious trade in smuggling vile rum and poor cigars.

The Gulf coast line of Florida, Alabama, Mississippi, Louisiana, and Texas is more than 6,000 miles in length, being about 1,000 miles longer than that of the Middle Atlantic States. Of this extent Florida has nearly 3,000 miles, or about one-half. A statistical review of the U. S. Fish Commission, published some ten years ago, says:

> The Gulf States occupy a favorable location for supplying a large part of the country with marine products. A dozen or more States in the Lower Mississippi Valley have their nearest coastal connections through these States, and it will probably be in response to this section's demand for marine food products that the Gulf fisheries will reach their highest development.

The fulfillment of this prediction has been realized, for at present a large demand exists for the food-fishes of Florida in all the South Atlantic States, while the choicer varieties, as red snapper, pompano, Spanish mackerel, etc., are shipped to all the principal northern cities. The same report says:

> This region is favored with many highly esteemed food-fishes, which occur here in greater abundance than elsewhere on the coasts of the United States. The undeveloped resources of the Gulf States invite outside attention and afford a promising outlook for future increase. The possibilities of the region in the matter of oyster production and cultivation are believed to be great.

Few sections of the United States are better supplied with desirable and important marine-fishery products, including fish, reptiles, and invertebrates, than the Gulf States. Among the invertebrates the oyster ranks first in commercial importance. It is extremely abundant throughout the entire section and constitutes the most prominent fishery product. No other mollusks have as yet attained economic prominence, though in Florida the round clam or quahog is taken in small quantities, and the meat of the conch is used for bait and eaten locally. A number of species and varieties of sponge occur off the Florida coast, and are objects of an important fishery, the only one of the kind prosecuted from the United States. Among crustaceans the shrimp is the most prominent. Crabs are abundant in this region; in addition to the common blue crab of the Atlantic coast, there occur the shore crab, the lady or sand crab, and others of less importance. The stone crab, which reaches a large size and is very palatable, is probably most abundant on the coast of Florida.

The economic value of the reptiles inhabiting the Gulf States is greater than in any other section. Foremost among them is the alligator. There are at least five species of terrapins in this section which are valuable as food. Four of these occur in fresh water. The salt-water or diamond-back terrapin is also found in the salt marshes from Florida to Texas, and is a valuable article of fishery. This region is included within the range of three soft-shell tortoises. Two species of snapping turtle also inhabit the fresh waters of these States. Three important marine turtles frequent the Gulf of Mexico and are sought by the fishermen; these are the green turtle, the loggerhead, and the hawkbill or tortoise-shell turtle.

From the foregoing brief account of the fishery resources and kindred industries of Florida, it is evident that the present active demand for fish, oysters, etc., will be largely augmented in the future, especially in view of the fact that there is a material decrease in the supply of these products in northern waters; indeed, there are already many northern fishing smacks in Florida waters every winter, and lately there have been oyster-grounds located and taken up by northern parties with a view to an increased cultivation of oysters. The granting of these privileges should be paid for by the parties interested and made a permanent source of revenue to the State, the same as is done in the States of Virginia, Maryland, New Jersey, New York, etc. This is very important and should be attended to before the best grounds are disposed of gratuitously. A State fish commission could be supported by the revenue derived from the rental of oyster-grounds alone, and there should be an intelligent supervision of this branch of the fisheries, in order that those interested may keep pace with the improvements and discoveries that are yearly being made in the cultivation of oysters and be better enabled to foster this important industry.

The same necessity exists for an able and competent supervision of the sponge interests, in which Florida alone is concerned, for in the waters of that State are the only sponge-beds in the United States. It is of vital importance, then, that those beds should be properly protected, the taking of the sponges subjected to wise and judicious surveillance, and their cultivation prosecuted with vigor and intelligence in order that the supply may be maintained and increased, and the revenue to the State consequently enhanced.

The shad fishery of the St. Johns River constitutes one of the most important branches of Florida fishing industries, as the first shad of the season are shipped thence to northern markets at a time when they command the highest price. As the supply has lately been seriously decreasing, it is of paramount importance that the yield should be increased by artificial means. The artificial propagation of shad has been attended by more pronounced success, perhaps, than that of any other fish, a most convincing example being that inaugurated by the United States Fish Commission in California, where, by the planting of less than a million shad fry in the Sacramento River a few years ago, shad have become so numerous that they are now sold for a less price than in eastern markets. When it is considered that prior *to*

this experiment there were no shad whatever on the Pacific coast, the argument in favor of the artificial culture of the shad is incontrovertible.

The State of Florida should have at least one hatchery on the St. Johns River, and as the shad-hatching season lasts but a couple of months, the expense is trifling, while the results are all important, far-reaching, and most bountiful.

There has been also a considerable decrease in some of the coast fishes, while a complaint of the scarcity of the best food-fishes in the inland waters of the State is universal. Now is the time to do something toward a restoration of the fish supply to these waters, or at least to prevent a further depletion by the proper and fostering care of a competent fish commission—one that is able to cope with the situation and to apply the proper remedy, whether it be by artificial cultivation or by increased protection, and by so doing to increase the food supply of the people.

In the Northern States the fishes of many of the interior streams have either been totally destroyed or very materially decreased by the pollution of the streams through the refuse and offal from manufacturing establishments. It would be the part of wisdom for the Florida authorities to be forehanded in this matter, on the principle that "an ounce of prevention is worth a pound of cure," and to enact such laws as will prevent a like decrease of the fish supply from similar causes.

The United States Fish Commission has done considerable work in Florida, and will do a great deal more; and it is also contemplated to establish a station for the cultivation of fish, oysters, sponges, etc., at no distant day. In view of such an event, therefore, it is all the more important that good protective laws and their effective enforcement by a competent State fish commission should be provided for, otherwise the work of the National Commission would be to a great extent rendered useless.

It will be readily seen, from what has been said, that it is of the utmost importance that the fishery industries of the State should be looked after by an efficient and competent commission. It has been thoroughly demonstrated in the many States, and particularly in Florida, that the plan of a complimentary fish commission, composed of several persons who receive no compensation, has not worked advantageously, although liberal appropriations were annually made in the older States. Too often such commissions degenerate into mere political machines for the securing of votes, while the legitimate work of the commission is neglected or frustrated. It can not be expected that men will give much time or attention to duties for which they receive no compensation, so it follows, as a matter of course, that if they can not command dollars they will command votes, if possible.

The fish commission of Florida is virtually obsolete at present, for, notwithstanding the appointment of three commissioners several years ago, as provided by law, I have learned on good authority that nothing has been done by them and that to all intents and purposes the commission has ceased to exist.

What is needed is the enactment of a law that provides for the appointment of a single commissioner of fish and fisheries at a fair salary, one who has a scientific and practical knowledge of fish and fisheries and is fully competent to deal with the subject in all of its bearings. Such a person would be able to materially augment the revenue of the State by an increased development and a more abundant yield of the various fisheries. If thought best, he might also have supervision of the game birds and mammals and see that the laws for their protection were enforced.

BOZEMAN, MONTANA.

# NTERNATIONAL PROTECTION FOR THE DENIZENS OF THE SEA AND WATERWAYS.

By BUSHROD W. JAMES, A. M., M. D.

It is clear to the thoughtful mind that there is a yearly increasing necessity for ɔnomy in several directions, none of which is more decidedly marked than that ncerning the denizens of the sea. That a deplorable mistake has been made by ɔn and corporations in hunting the whale, walrus, and seal, until the first two are nost exterminated, while the like danger regarding the other is now agitating a eat part of two continents, is sufficient apology for the reiteration of the theme ected for this paper.

Impelled with a keen desire for wealth, men will not pause to think that there is a ious menace to human existence in the wholesale destruction of any animal upon ıich it has relied for sustenance and clothing, not to mention warmth and shelter. ɔr can they realize, when vessels return from whaling voyages with cargoes insuffi- nt to meet expenses, that the decreasing animal population of coast and island on ɔir routes is due to the same cause. The animals have been hunted too greedily d have either been destroyed or driven from their haunts, leaving men destitute ıo have always depended upon their annual return for nearly every life necessity. one can accurately estimate the sufferings that have resulted in times past in ninishing numbers of Indians and Esquimaux along these seaboards; and common ıtice questions, is it right to take for one man's gain the food supply of inhabitants American soil, bringing helpless fellow creatures to starvation and death.

Careful study will show that however valuable oil, whalebone, or ivory may be to mmerce, a judicious economy in their production must be more advantageous to a ɔadily lucrative business than could be a few years of surprising overproduction d an aftermath of no returns for expensive expeditions. Such reports have come ɔm the whaling fleet sent out from San Francisco in the last two years at least. It ıs due to want of success that the whalers are now ice-bound and in danger of death the great frozen Arctic Ocean. Possibly if whaling and walrus hunting (or, as it called, ivory hunting) are legally forbidden by the United States Government and ussia and Canada for a time, the great mammals will return to their old foraging ıd breeding grounds. If not, the dealers in such articles and the men heretofore ıgaged in the capture of the animals may look upon their occupations as practically scontinued for all time.

In support of this we need only point to the western plains, over which once amed buffalos and antelopes by the million. So plentiful were the herds that the ɔrtsmen of the world came to aid us in their extermination. Even if the plan for e protection and reproduction of the buffalo succeeds, which is doubtful, neither

this generation nor the next will live to see its consummation. So with the sea mammals of which we have spoken. If to-day legislation stepped forth with its utmost power to protect, there will yet be years of unprofitable voyaging in the northern seas before they once more become plentiful. The belated arrangements relative to fur-seals in Bering Sea must be carefully carried out to insure any great commercial advantage from them in the future. The seal, whale, and walrus produce but one at a birth, the exception never being met in the seal, and if the others ever bear more there are but two, and these events happen but once in a year. Therefore, provided that a million seals are spared, and each cow is productive, the increase could be at the very utmost but one to every ten animals, and this, allowing a great percentage of the million to be females, the number of which never predominates to so great an extent.

It is plain, therefore, that the larger animals upon which whole populations have depended for food and other life necessities, i. e., the three most valuable denizens of the sea, must at once receive adequate protection or they will be destroyed beyond remedy in a very short time. Cooperative international agreements are necessary whereby the creatures will be safe from molestation, not only on their breeding-grounds but wherever they gather. We maintain that they belong to the countries upon whose territory they congregate for the purpose of carrying out nature's great design, and that there each government should execute the utmost prerogatives to secure safety for its property without any outside assistance, but only by peaceful international legislation can deterioration and future extinction be avoided. By no means do we mean to insure these animals alone from injudicious hunting, nor indeed do we desire to express belief that they are the most important denizens of the water. For only commensurate to their value to certain inhabitants can their true usefulness be adjudicated, as likewise that of the salmon, cod, halibut, shad, herring or any other fish equally important for commerce and for food. Except that the inhabitants of the northeastern part of the United States, as also those of Nova Scotia, Newfoundland, etc., are within reasonable distance of inland towns, their dependence upon the numbers and condition of the returns of their fishing fleets is almost as great as that of the Esquimaux upon the seal, whale, and walrus hunting.

If then those fisheries have become of national and international importance the people of the eastern districts should have their fishing interests equally well guarded from injury. Left to their own devices, the true fisherman—one born to the trade and relying upon its success—will be careful not to injure his future prospects by endeavoring to catch all the fish at one great sweep. Nor will he waste the other fish that enter his net among the more valuable kinds. Instead, he will cast the flapping, gasping, wide-eyed strangers back into the water, there to perform their part in the world of nature. Therefore, it is not among the life hunters and fishermen that we must look for the destroyers of the fish or mammals, but to men or companies who take spasmodic interest in them for a time, simply as a money-making scheme. The protection and propagation of the more desirable food-fishes seem to have become established sufficiently to remedy many of the evils heretofore existing, but trouble still exists and will continue so long as indiscriminate catching is permitted.

The reasons for this are obvious. Some years ago there was a company (or companies) formed called the "Menhaden Fisheries," ostensibly for taking menhaden, a comparatively useless fish, whose reputation was to be redeemed by making oil and

compost of the enormous catches of this fish off the Atlantic coast particularly. Admitting that the important fish, such as shad, leave the waters of the Atlantic rivers and are consequently safe during their absence, how can it be credited that the great nets full of menhaden are not very largely mixed with young food-fishes? Or, even if that is not so, must we not concede that menhaden, though unfit for human food, are in some shape the chief food for edible fishes—if not as full-grown animals, possibly in the form of spawn and quite young fish. It must be thus that they are useful, and consequently their wholesale and relatively useless destruction is a great wrong, which should be suspended at once by international agreement. Besides, there is a touch of extreme cruelty in hunting them simply for the sake of pressing them into the service of the farmer, for whom, indeed, they may be a cheap, but not altogether desirable, compost.

There is another danger, of which the fisherman may not be conscious, and that is the destruction of the young of salmon, trout, and other very desirable fishes which have been placed in the Delaware and its tributaries, as well as in other great rivers near the coast. It was a known fact that the fry were deposited therein, but their non-appearance after reasonable time led to the belief that the enterprise was not a success. But recently the beautiful swimmers have been seen, having returned after a long absence, or else after having lingered in other streams or ocean haunts. More probably they went out to sea while developing into full growth, and they now return to spawn upon the grounds wherein they found their first home from the hatcheries. It is not for us to say whether they remembered their home or whether only the impulses of nature drove them up toward shallower waters. Suffice it that we are safe to claim that they belong to the society which so carefully propagated and deposited them or to the country for which it acts, and thus they become, as it were, wards of the government and subject to its protective legislation. This shows that national laws are absolutely requisite to their preservation from local fishing enterprises or from even individual fishermen.

Further, we are assured that the many valuable food-fishes are daring wanderers, roaming far out to sea, while they are not impelled toward the spawning-grounds. Thus the herring, mackerel, or cod of British Columbia may later become the supply for Maine and Massachusetts. Consequently both countries interested should make complementary rules regarding the protection of these fisheries, having unquestionable legal rights in the matter. That such is truly and reasonably requisite is evident in the lesser quantity and smaller size of the product of these fisheries. So, too, has the lobster deteriorated, until a large specimen is rather the exception than the rule, as it used to be. To-day salmon, cod, and other fish are wonderfully abundant, but unless Canada joins with the United States toward making strict laws regarding the time of fishing, the numbers taken, and economy of sparing the young and returning the living but undesirable fishes to the waters, there will come disastrous days for the salmon canneries of the Northwest, as well as for the fisheries of the Northeast. Just international protection is the only mode of preventing depletion.

Indiscriminate fishing should not be allowed at any time, and no corporation should use means by which great numbers of the denizens of the water may be captured for other purposes than to supply food to human beings. Fish laws, both national, State, and international, should insert warning clauses regarding wasteful destruction of the denizens of the sea, lake, or river. The public should be given to

understand that the propagation of food-fishes is but in its infancy, and that it will take some years to attain great results, and strict care is necessary to insure success; but when the different species are established legal permission ought to be given for fishing in different streams and for different fish. We are confident that when pelagic sealing has become amenable to international laws the business will cease; and as surely when salmon, cod, herring, mackerel, shad, and all other far-wandering fish are protected by the same union of nations for their safety none but legalized fishing will be attempted, and thus the continuous success of all such fisheries will be secured and revenue for country and individual will grow proportionately.

Justice and right grant that man is the owner of all inferior animals and that for his food, clothing, and other necessities he has the unequivocal right to slaughter either animals or fish sufficient to supply his needs, but there is something repulsively cruel in the wholesale destruction of either one or the other for imaginary or artificial requirements. It is against this particularly we would lend both pen and voice, for truly nothing was created to be so ruthlessly demolished. That we have not discovered the use of every living thing does not prove that aught was given life in vain. Therefore let the Fish Commission raise its voice against the cruel destruction of any living thing over which its prerogatives may reach, thus securing safety not only for the wards of their hatcheries but for the food supply for them and other creatures.

That the waters of the partially settled Northwest teem with the most desirable food-fish does not insure their perpetuity against waste nor prove that they will not diminish in numbers when increasing population conjoins with the industries devoted to canning, salting, or drying, even if the business should be operated with economy. The swarming millions are the natural accumulation of centuries of almost uninterrupted reproduction, natives of the country catching only sufficient for their own needs and for the comparatively small trade with the outside world. As the settlement of the country increases there will be gradual diminution of numbers, however carefully the fishing interests are guarded. But if the plan of systematic economy begins at once, there will be no very disadvantageous falling off of the most valuable kinds.

We have used the Northwest as an example of the plenitude of nature's food supply only because the trend of business and commerce leads in that direction, but we could as readily use the Northeast with its former millions of valuable denizens of the bays and rivers and seacoast. Now the cod fisheries are disappointing, sometimes the mackerel and herring fail to appear in great numbers, and the fishing villages suffer in proportion. Once, too, the great Chesapeake became choked at seasons when many noble fish swarmed toward their breeding-grounds. It has been written that bushel baskets were filled and sold for no more than one fine shad would cost to-day. The stories of the abundance and cheapness of terrapin compare oddly with the enormous prices to which they have risen, making an expensive luxury of what was once a drug in the markets of Maryland. Bearing these authentic assertions in mind it is safe to say that the Fish Commission has not begun its work too soon unless the people were willing to have the best of all fish become extinct, for neither shad nor salmon, nor any other fish, could hold out against the enormous catches once permitted on the Delaware and Chesapeake, as they are now on the Columbia and Willamette.

The idea ought to be suggested that, though the interests of more than one or two nations might make international unity relating to the safety of the seal from destruction very necessary, it could not well include the true fish within that jurisdiction. A

moment's consideration will show the mistake in this. The true fish are nearly as nomadic as the whale or seal and personal property is as readily assured in the one as in the other, in proof of which we may note the salmon before mentioned, the fry of which was placed in the Delaware and other rivers, whose total disappearance for about five years caused the belief that the planting had been a failure, when the discovery of well-grown healthy salmon in those rivers proves that they wandered out to sea, returning when nature directed them to the shallower and less tempestuous waters, presumably for the sake of reproducing their kind. The same can certainly be said of other fish, and doubtless the assertion is true that the mackerel, herring, cod, and halibut of the lower shores belong to the same shoals or schools as those that later swarm to the nets of the Canadian fishermen. Only international protection can secure immunity from future depletion if this be so; and this must not be a threatening attitude of one nation toward another, but a mutually amicable agreement, providing that a given number of vessels shall be permitted to fish during fixed legal seasons. At first this may look like a tyrannical blow to the men who depend upon these fisheries for a livelihood, but the result will soon show that such legislation would secure successful catches every season.

History will show that the times of disaster, when but few returns are obtained, have in nearly every case succeeded phenomenally enormous catches. Perhaps the bad season does not come directly after the good one; but examine the reports and they will show that large returns have induced a great number of vessels and men to engage in the business, prospect of gain being the incentive to the industry, until in a few years the overproduction results in a falling off, bringing trouble and distress to the towns and villages to which the enterprise naturally belongs. Since the fishermen of Galilee deplored their long nights of useless toil and waiting for nets to fill there have been men disheartened by failure and consequent distress. The days of miracles have passed away long since, but the increase of intelligence in late generations and the development of talent and genius were, no doubt, intended to supply their place. The law of humane justice must come to the relief and encouragement of our fellow-men, and in no way can this be secured with regard to the fisheries except through an agreement between countries whose contiguous possessions give them equal interests in the inhabitants of the sea or its tributaries. There must not only be laws limiting seasons, but vessels and men, so that no one nation possessing greater facilities for hunting shall take all the fish and leave little or none for their neighbors.

International consideration should have been directed to the seal fisheries as soon as the United States made the Territory of Alaska its own. Had that been done the animals would not now be so near extinction. It is sincerely to be hoped that the Fish Commission will not only take these universal protective measures into consideration, but that it will urge such legislation upon the intelligence of the proper authorities, else the efforts now made to propagate and greatly increase the number of desirable fish will be eventually futile, as the augmenting quantities will only tempt capital to hurry a war of extermination in the effort to secure all that skill can obtain in a given period. Neither threat nor watchfulness can secure protection half so easily as a friendly understanding upon the subject, which would unquestionably result in an international arrangement tending with equal favor toward the good of everyone engaged in any and every branch of the fisheries.

But the protection of fish and other useful water animals must extend farther

than a legalized regulation of the fishing season or of the numbers taken; nor will returning unsalable fish to the water quite answer the purpose. Wise protective laws should also be made and enforced by neighboring nations against the pollution of bays, rivers, inlets, ponds, or streams by offal, garbage, chemicals, oil, or any kind of rubbish. Mills in which dye is used should not be allowed to discharge the refuse water into rivers or even small tributary streams containing food-fish, nor should any manufacturing enterprise use the waterways as waste-receivers. I note that the laws make mention of the northern logging season, when millions of logs float on fishing waters in Canada and in our own extreme Northeast and Northwest. This seems to be requisite, but it will not do to toss slabs of bark, decaying logs, or broken lumber, or sulphur-charged coal dust on neighboring shores to accumulate as rubbish until storms sweep them again into the streams with augmented power to annoy and sometimes destroy the fish, otter, beaver, or whatever may inhabit the waterways.

Nearly all safeguards for the inhabitants of the sea or river will be found to conduce to the general public good as well. Decomposing refuse, whether of animal or vegetable growth, is usually poisonous, working with subtle force upon humanity and breeding pestilential fevers. Dyes are often composed of poisonous material, and they may injure the water used for drinking without marring its transparency. Thus the thoughtful observer readily sees that the requirements of the Fish Commission and the boards of health conjoin, although one protects human health and the other the production of edible or otherwise useful animal life. As for interfering with manufacturers by legislating against dams, they could in every case be so constructed as to allow of a broad waterway for the fish when they enter the inland streams; but this needs vigilant watching. There can be no doubt that the plentiful supply of salmon and other wandering species is largely due to perfect freedom of action in their native haunts. They have spawned when they would, they have roamed at their will, and with little destruction except that resorted to by man. No nets, no weirs, no dams, no vast heaps of polluted débris have prevailed against their freedom in the northwest streams. Time was when Canadian and northeastern waters were equally prolific. The contrast shows plainly how carefully British Columbia, the United States, and South America should join in the preservation of a most valuable product of every nation with rivers and a seacoast.

To-day I would suggest legislation that would preclude the possibility of the beautiful and prolific waterways of our territory, no matter where, from being clogged with rubbish, poisoned with refuse, or blocked by dams and traps. A short time spent in selecting sites for manufacturing towns would secure the proper requirements without wholesale destruction to inferior life. If the effect of perfect protection can not be obtained, the next best thing would be to forbid the use of water polluted by factories as well as the fish therein. But the disastrous drawback to that would be a neighborhood poisoned with effete matter accumulating for years. There will always be fishermen, and there will also be people to consume the fish found by the sportsman; therefore the best way is to keep the waters pure and continue the hatcheries. Legislation will be of no avail, so far as a great part of the United States is concerned, if not agreed to by all States and contiguous countries. In fact the fishing, fur, ivory, whalebone, and oil interests of the whole continent demand international cooperation for the successful protection of the denizens of the sea and other waters extending into it from the shores. With this continental agreement and an American alliance

with Russia, Great Britain, Japan, and China for the protection of the great animals of the Pacific, on the west and north, with a like agreement with the owners of Greenland and its island borders and Newfoundland and its neighborhood on the northeast, it would yet be possible to have abundance of all valuable products from the oceans and their tributaries which sparkle in a beautiful, silver network throughout the length and breadth of the lands adjacent.

Many wise individuals to-day deplore the dilatory attention to national interest that has resulted in comparative extinction of many really valuable creatures, whose abundance seemed but a few years ago to be inexhaustible. Should not everyone energetically lend his voice and influence to prevent further loss to both individual and Government? A war of extermination of the human inhabitants of remote corners of the country would justly be considered a heathenish, cruel outrage; but is not the destruction of lower animal life in vast multitudes equally cruel? If mankind has its sources of life necessities cut off, they pine and die. Thus we, as a congress, should urge full legal protection, through both home and international laws, for the food-fish upon which a vast number of human beings depend for all that makes life comfortable; while in some places, neglect to pass such laws actually results in suffering and death. We do not deem it right to propose the protection only, but should follow the proposition up by active, earnest work for the desired and needed results.

PHILADELPHIA, PENNSYLVANIA.

# THE RESTRICTED INLAND RANGE OF SHAD DUE TO ARTIFICIAL OBSTRUCTIONS AND ITS EFFECT ON NATURAL REPRODUCTION.

By CHARLES H. STEVENSON,
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There is no species of fish more important to residents of the Atlantic seaboard than the shad, and none whose preservation so immediately concerns a larger number of persons—24,768 men being actively engaged in this fishery in 1896. True, the yield of codfish is heavier and sells for a greater value, but the fishery for that species is confined to one section of the coast, gives employment to less than half as many men, and its prosecution requires costly vessels and appliances, necessitating lengthy trips from port, with much exposure and loss; whereas, shad occur more or less abundantly along the entire coast, ascending the rivers as far as they permit, almost to the very doors of fishermen and consumers, several hundred miles from the sea, and are caught by all forms of apparatus, from the costly pound nets and seines near the coast to the roughly constructed bownets and falltraps in the headwaters. Yet, there are few species whose geographical range and local abundance are more easily affected by artificial agencies or which require greater attention for their maintenance, and as most of the important shad streams border or traverse two or more States and are thus subject to more than one jurisdiction, the agencies affecting their range and abundance present an appropriate subject for consideration in a gathering of representatives from the different States.

No river on the Atlantic seaboard appears too long for shad to ascend to its headwaters, provided they meet with nothing to bar their progress. They ascend the St. Johns in Florida a distance approximating 375 miles; the Altamaha, 300 miles; the Edisto, 281 miles; the Santee, 272 miles; the Neuse, 300 miles, and the Delaware River a distance of 240 miles from the sea. However, these distances do not equal the extreme ranges in the early part of the present century. Then shad ascended the Savannah to Tallulah Falls, a distance of 384 miles, instead of 209 miles as at present. They ran up the Pee Dee to Wilkesboro, a distance of 451 miles, whereas the present limit on that river is Grassy Island, 242 miles from the sea, and only one shad was reported from that point in 1896. On the James River the former run was 350 miles in length, while the present limit is Boshers Dam, 120 miles. The greatest decrease exists in Susquehanna River, in which shad formerly ascended to Binghamton, 318 miles from the mouth and 513 miles by water-course from the sea, whereas at present they do not appear to pass beyond Clarks Ferry, 84 miles from the mouth of the river.

From Table A, on page 270, it appears that in 23 of the principal Atlantic coast rivers, aggregating 8,113 miles in length, shad formerly existed throughout 6,052 miles,

or 74 per cent of the length; whereas at present they are to be found in only 4,107 miles, a decrease of nearly 2,000 miles. This summary comprises only the principal rivers, and if minor streams and tributaries were included, the total length from which shad have been excluded would doubtless appear more than twice as great. In much of that length shad were quite numerous, the catch in many instances exceeding the yield in the portion to which the fisheries are now confined. The upper section of the Pee Dee is supposed to have yielded over 100,000 annually. In the James River, according to the late Colonel McDonald, the annual catch of shad in the 230 miles from which they are now excluded "was at one time far in excess of the now (1880) entire catch for the whole river." The present excluded length of the Susquehanna formerly yielded several hundred thousand annually. In a report of the special commissioners of Massachusetts appointed in 1865 to investigate the fisheries of that State, it was estimated that at the beginning of the present century the annual shad yield in the Merrimac River ranged from 500,000 to 1,000,000 in number, whereas none ascend that river at present.

The limitation in the range of shad in the rivers is the result of several agencies in addition to the size of the stream, the most important of which are (1) natural falls, (2) artificial dams, (3) pollution of water, (4) agricultural operations, and (5) extensive fisheries.

Natural falls exist at the escarpment line in all of the rivers having their sources above the coastal plane, but in only a few instances are they of sufficient height to form insurmountable obstacles to the range of the shad, among these being Great Falls on the Potomac and Bellows Falls on the Connecticut, which form absolute barriers to the further progress of shad that may reach these points, excluding them from the whole of the river above. Most of the other Atlantic coast streams having their sources above the coastal plane have been made impassable at a short distance above the escarpment line by means of artificial dams for developing water-power or for navigation improvements. In this class are the Savannah, the Santee, the Cape Fear, the James, the Susquehanna, the Housatonic, the Connecticut, the Merrimac, the Kennebec, and the Penobscot. The lengths from which shad are excluded appear in Table A on page 270.

Access to suitable spawning areas being a physiological necessity for the maintenance of the fisheries if natural reproduction is depended on, and as many of the spawning-grounds are located in the headwaters of the rivers, it follows that while the exclusion of shad from the upper sections is the immediate it is not the most important effect of those obstructions. It has been the common experience in all the shad rivers that whenever a high dam or other obstruction has been erected across the stream the fisheries above that point have at once ceased, and those immediately below have for a year or two flourished on the large number whose ascent has been stopped by the barrier and then they, too, have declined. It also appears that the extent of this decrease below the dam is largely dependent on the distance of the obstruction from the mouth of the river and the proportion of the spawning-grounds to which they are denied access, and if all the breeding-grounds have been cut off in a definite coastal region the shad have almost entirely disappeared.

This is clearly illustrated by the conditions on the Connecticut River. The erection of the Holyoke dam in 1849 prevented the fish from ascending above that point and as they strayed about in the river below the obstruction they were taken in greater abundance than formerly. At the Parsonage fishery near the mouth of the

river and 40 miles below the dam, the average shad yield during the 20 years preceding the erection of the obstruction was 9,854 annually; during the 5 years following 1849 the annual catch averaged 19,490; during the next 10 years it was but 8,364, and for the following 6 years, 1864–1870, the annual average was but 4,482 shad, less than one-half the former yield. The record of the total catch on the Connecticut from 1853 to 1896 shows that the yield below the dam decreased from nearly half a million annually to an average of less than one-tenth of that number. In a few rivers the development of water-power has resulted in completely exterminating the anadromous fishes, this being the case in the Thames, the Blackstone, the Merrimac, the Saco, and other rivers. However, instead of the employment of a few hundred persons in taking fish each spring, the water-power on those streams affords employment to thousands of mill operatives.

Numerous attempts have been made by the erection of fishways to enable shad to pass above these obstructions, among the costly contrivances being those in the Savannah at Augusta, the Santee at Columbia, the Potomac at Great Falls, the Susquehanna at Clarks Ferry, the Housatonic at Birmingham, the Connecticut at Holyoke, the Merrimac at Lawrence, and the Kennebec at Augusta. The fishway in the dam across the Santee at Columbia, built in 1883, consists of 3½ sections, 36 feet long, with a total rise of 9 feet, and is of the type known as the McDonald fishway, consisting of two sets of buckets, straight wooden buckets to receive the water in its downward flow and curved iron buckets to direct this water back upstream, thus affording a comparatively quiet waterway. It is fairly efficient for certain species when kept free from trash, but shad do not appear to use it.

In 1882 an appropriation of $50,000 was made by Congress for the erection of suitable fishways at Great Falls in the Potomac where the river descends almost abruptly 35 or 40 feet. In 1885 the work of construction was begun, but it was soon abandoned, it being decided that "the fishways were not found sufficiently strong to withstand the effects of the violent floods of the locality in which they were placed."

The fishway over the Holyoke dam on the Connecticut River, one of the largest and most expensive in the country, was built in 1873 after the Brackett plan, a modification of the Foster fishway. It is 440 feet in length, so divided into compartments or bays, by means of T-shaped partitions extending at right angles to the sides, that the water winds through a long, circuitous course, running about 1,500 feet before it emerges at the lower end. As the height of the dam is 30 feet, the fall of the water averages about 1 foot in 50, with little momentum. But it does not appear that shad have ever passed through this fishway in any numbers.

An account of the construction of fishways in the Columbia dam on the Susquehanna River illustrates the difficulties of making these obstructions passable. This dam is only 7 or 8 feet high, and its disastrous effect on the shad fisheries of the Susquehanna has attracted very general attention to it. The original charter required that a rafting channel should be left in the obstruction. In 1865, in accordance with an act of the Pennsylvania legislature, the company removed a 40-foot section of the dam, and in that space built a new subdam, the top of which was about level with the water below. The lower slope of the subdam was placed at an inclination of 1 in 15, and the sides of the aperture in the main dam were dentated, so as to promote the formation of eddies in the current. This construction did not appear to answer its purposes, and in 1873 the State made an appropriation for another fishway at that point after plans modified from numerous designs submitted in competition. That also

proved ineffectual, and in 1880 a fourth passageway was placed in the dam, this one consisting simply of an opening 125 feet wide, this plan being chosen because it conformed to a natural break, experience having shown that shad passed through such an opening more readily than through any regular fishway that had been constructed. But it is only in very low and little-used dams that such breaks can be made without injury to the original purpose.

Although the above-described fishways are modern constructions, designed by engineers of ability, familiar with the principles of hydraulics and the habits of fish, yet none of them appears to be successful for shad, this fish being so timid that it will not enter fishways readily used by salmon, alewives, and other species. True, a few individuals may pass through some of the fishways, but the number is not sufficiently large to be of any practical value, and in a majority of instances where shad are reported above a dam they have swum over the crest during freshets or have passed through breaks in the obstruction.

The utility of the spawning areas below the dams has also been impaired by chemical, sawdust, and other refuse from mills and towns on the river banks. In a number of small streams these have almost completely destroyed the spawning and feeding areas, but regulations against this practice now exist in most States.

Increased agricultural operations have also had some effect on limiting the range of shad up the rivers. At the time of the settlement of the river valleys most of those areas were covered with forests and the ground was carpeted with leaves and moss, which checked the surface flow of water and restricted its evaporation, thus tending to constancy in the flow of rivers; and freshets were rare and of insignificant proportions. With increase of population the forests were cleared away and large areas of land brought under cultivation, causing injurious meteorological changes and more numerous and destructive floods. During heavy rains the plowed soil upon the hillsides is easily washed into gullies, through which the water is quickly conveyed to the rivers, filling them beyond their capacity and bringing into them masses of earth and other débris, thus covering the spawning-grounds. The freshets are soon over, and the flow of water in the streams becomes so small that shad are not induced to proceed so far up as formerly.

On some of the southern streams decreased navigation has resulted in reducing the length of shad range. This is especially true of the Combahee, the Ashepoo, the Edisto, the Chickahominy, the Mattaponi, and the Pamunkey, the channels of which are now much encumbered with drifting logs, overhanging trees, brushwood, and shoals of loose, shifting sand, through which a passageway for the ascent of fish was formerly maintained by navigation and the rafting of timber.

The most important factor in reducing the inland range is the extensive fisheries near the coast. In the first half of the present century shad were caught all along the river course, every point yielding its quota for local use and the limited demand not warranting the prosecution of the fisheries so vigorously as to cut off the "run" at points above. But the profits derived from shipping shad to populous centers resulted in a concentration of the fisheries at points near the mouths of the rivers where most convenient shipping facilities exist, resulting in certain narrow streams in practically excluding shad from the middle and upper sections where the spawning-grounds are located. The effect is not so apparent as in the case of impassable

dams and natural falls, for the latter form absolute barriers, whereas extensive fisheries merely limit the number of fish ascending to the extreme range of the river and not the length of that range; yet in many cases they affect the future abundance of the species even more than the dams and natural falls. This is particularly noticeable in those narrow streams whose fluvial characteristics extend nearly or quite to the sea, as in most of the rivers between the St. Johns and the Neuse, and to some extent in the Susquehanna, the Hudson, the Connecticut, etc. In the Ogeechee, Savannah, Edisto, Pee Dee, and Cape Fear, the great bulk of the catch is obtained in the extreme lower end within 30 or 40 miles of the sea, and comparatively few shad ascend as far as the spawning-grounds. In the Connecticut nearly all the shad are caught within 20 miles of the mouth. The dams in those rivers perform a very unimportant part in limiting the run of fish, for few shad ever reach those obstructions.

In the broad estuaries tributary to the sounds of North Carolina and to the Chesapeake and Delaware bays the effect of netting is not so apparent, yet even in those waters only a small percentage of the shad ever reach the spawning-grounds. Formerly the great bulk of the yield was obtained from the middle and upper sections of the rivers, while at present nearly all the catch is obtained in the lower section and in the salt water of the estuaries. The extension of the fisheries into the estuaries is of recent origin, dating only from the middle of the present century, and their development has been principally during the past twenty years. It requires large and costly apparatus to prosecute the fisheries there, and forms suitable have come into use only quite recently. With the exception of drift nets in Delaware Bay, New York Bay, and one or two less important places, and the mackerel purse-seines, which take a few shad on the New England coast, pound nets and stake nets are the only forms of apparatus employed in catching shad in salt water. Over 90 per cent of the shad caught in the salt water of the Chesapeake region are taken in pound nets, yet the use of that apparatus there dates only from 1865, and not until 1875 were they extensively employed. Stake nets and pound nets, which catch practically all the shad taken in the salt water of North Carolina, have been used in that region only since 1865.

At present nearly one-half of the total shad yield on the Atlantic seaboard is obtained in salt water, and those fisheries are becoming more extensive each year. Table B, on page 271, shows that in 1896, 6,252,464 shad, over 47 per cent of the total yield, were caught in regions which half a century ago yielded none whatever; this in some measure compensating for the 4,000 miles of river-course from which they are now wholly excluded and the lengths from which the exclusion is partial. It thus appears that the principal change in the fisheries during the past fifty years has been one of location rather than extent of the total yield, the great increase in the estuaries compensating for the decrease in the headwaters. This change in the fishing-grounds results in a large portion of the fish being taken before they reach the spawning areas in fresh water, thereby preventing them from adding their quota to future supply almost as effectually as though they were excluded therefrom by means of dams or otherwise. But the same result is accomplished when the fish are caught after they have reached those areas and before they have spawned. Furthermore, moving the seines and other apparatus of capture over the spawning-grounds disturbs and drives away the fish from those areas, and also destroys many of the eggs and young shad already there.

Access to suitable spawning-grounds in sufficient numbers to compensate for loss by capture and natural causes is a physiological necessity for the maintenance of the fisheries if dependence is placed on natural reproduction. But from the foregoing it appears that the construction of dams has excluded shad from a large portion of the spawning-grounds, notwithstanding the erection of fishways in those obstructions; sawdust, chemicals and other refuse and agricultural operations have greatly impaired the utility of the spawning areas even now available, and the extensive fisheries have very largely decreased the number of the shad reaching those areas. These adverse agencies have reduced natural reproduction to almost an insignificant factor in the maintenance of the present fisheries and have rendered artificial propagation essential to their prosperity. During the seventies the returns of the fisheries reached a minimum; then the results of artificial propagation began to appear, not only restoring the former abundance of shad, but even increasing the catch.

The total shad yield on the Atlantic coast and rivers in 1880 numbered 5,162,315; in 1888 it was increased to 10,181,605; in 1896 it was further increased to 13,067,469, 29 per cent greater than in 1888 and nearly three times as great as in 1880. While this increased yield was preceded by an increase in the quantity of apparatus used, yet it was made possible by the greater abundance of shad, due to artificial propagation. Comparing 1880 with 1896, it is observed that the increase in the yield numbered 7,905,154. At 20 cents each, which is the average price paid by consumers, this represents an increase of $1,581,030 in the value, over 50 times the expenditures for shad propagation; a result probably unsurpassed in any other line of public appropriation. The large number of persons employed in this fishery and the present inability of natural reproduction to maintain the supply make it essential that no decrease be made in this important branch of fish-culture.

A.—*Summary of the original and of the present limit of shad range in twenty-three of the principal rivers of the Atlantic seaboard.*

| Rivers. | Distance of sources above coast line. | Original limit of shad run. | | Present limit of shad run. | |
|---|---|---|---|---|---|
| | | Locality. | Distance from coast line. | Locality. | Distance from coast line. |
| | *Miles.* | | *Miles.* | | *Miles.* |
| St. Johns | 375 | Sources | 375 | Sources | 375 |
| Altamaha | 450 | Macon | 370 | Hawkinsville | 300 |
| Ogeechee | 350 | Ogeechee Shoals | 200 | Millen | 100 |
| Savannah | 425 | Tallulah Falls | 384 | Augusta Dam | 209 |
| Edisto | 300 | Sources | 300 | Jones Bridge | 281 |
| Santee {Wateree | 350 | Great Falls | 272 | Great Falls | 272 |
| Santee {Congaree | 410 | Green River | 374 | Columbia | 233 |
| Pee Dee | 497 | Wilkesboro | 451 | Grassy Island | 242 |
| Cape Fear | 290 | Haywood | 210 | Stanley Falls | 181 |
| Neuse | 340 | Sources | 340 | Fish dam | 300 |
| Pamlico-Tar | 252 | Rocky Mount | 157 | Rocky Mount | 157 |
| Roanoke | 457 | Weldon | 249 | Weldon | 249 |
| James | 420 | | 370 | Boshers Dam | 140 |
| Rappahannock | 248 | Falmouth Falls | 155 | Falmouth Falls | 155 |
| Potomac | 400 | Great Falls | 190 | Great Falls | 190 |
| Susquehanna | 617 | Binghamton | 513 | Clarks Ferry | 279 |
| Delaware | 457 | Deposit | 256 | Burrows Dam | |
| Hudson | 314 | Glens Falls | 209 | Troy | 164 |
| Housatonic | 202 | Falls Village | 150 | Birmingham | 92 |
| Connecticut | 409 | Bellows Falls | 204 | Windsor Locks | 89 |
| Merrimac | 140 | Winnepesaukee | 125 | Lawrence | 20 |
| Kennebec | 155 | Caralunk Falls | 108 | Augusta | 44 |
| Penobscot | 255 | | 90 | Verona | 35 |

B.—*Comparative statement of the total yield and of the salt-water yield of shad on the Atlantic seaboard during 1896.*

| Water areas. | Total yield. | | Yield in salt water. | |
|---|---|---|---|---|
| | Number. | Value. | Number. | Per cent. |
| St. Johns River | 456,281 | $61,924 | 291,116 | 63.59 |
| St. Marys River | 10,193 | 1,754 | ..... | 0.00 |
| Satilla River | 1,500 | 240 | ..... | 0.00 |
| Altamaha River | 29,377 | 10,096 | ..... | 0.00 |
| Ogeechee River | 55,425 | 19,514 | 12,054 | 21.75 |
| Savannah River | 54,406 | 19,236 | 7,480 | 13.54 |
| Combahee River | 3,090 | 622 | ..... | 0.00 |
| Ashepoo River | 6,880 | 1,381 | ..... | 0.00 |
| Edisto River | 28,273 | 5,843 | ..... | 0.00 |
| Cooper River | 396 | 126 | ..... | 0.00 |
| Santee River | 7,309 | 1,547 | ..... | 0.00 |
| Winyah Bay and tributaries | 97,685 | 23,031 | 53,379 | 54.95 |
| Cape Fear River | 75,315 | 18,964 | 29,151 | 38.71 |
| Pamlico Sound | 448,089 | 109,727 | 448,089 | 100.00 |
| Neuse River | 207,052 | 39,067 | 82,238 | 39.72 |
| Pamlico-Tar River | 67,082 | 13,316 | 18,873 | 28.13 |
| Croatan and Roanoke Sounds | 169,541 | 33,201 | 169,541 | 100.00 |
| Albemarle Sound | 735,192 | 140,159 | 186,290 | 25.34 |
| Roanoke River | 169,409 | 20,489 | ..... | 0.00 |
| Chowan River | 183,545 | 34,422 | ..... | 0.00 |
| Pasquotank and Perquimans rivers | 41,579 | 7,898 | ..... | 0.00 |
| Chesapeake Bay | 1,638,844 | 167,929 | 1,428,327 | 87.15 |
| James River and tributaries | 495,762 | 51,247 | 100,379 | 20.25 |
| York River and tributaries | 546,548 | 50,361 | 182,375 | 33.69 |
| Mobjack Bay | 140,777 | 13,874 | 140,777 | 100.00 |
| Rappahannock River | 417,789 | 35,371 | 194,067 | 46.45 |
| Potomac River | 684,013 | 63,608 | 210,480 | 30.76 |
| Nanticoke River and tributaries | 216,288 | 20,667 | 42,405 | 19.60 |
| Choptank River and tributaries | 338,420 | 35,810 | 136,972 | 40.44 |
| Susquehanna River | 140,087 | 20,153 | ..... | 0.00 |
| Miscellaneous | 249,021 | 31,736 | 29,851 | 13.59 |
| Delaware Bay | 1,103,821 | 104,761 | 1,103,821 | 100.00 |
| Delaware River | 2,778,803 | 300,598 | 976,669 | 35.13 |
| Miscellaneous rivers | 134,838 | 21,147 | ..... | 0.00 |
| Ocean Shore of New Jersey | 16,240 | 3,518 | 13,765 | 84.75 |
| New York Bay | 216,425 | 30,941 | 213,925 | 98.89 |
| Hudson River | 602,858 | 83,237 | ..... | 0.00 |
| Great South Bay and Gardner Bay | 4,755 | 1,092 | 4,755 | 100.00 |
| Long Island Sound | 9,427 | 2,399 | 9,427 | 100.00 |
| Connecticut River | 51,690 | 9,508 | ..... | 0.00 |
| Miscellaneous Rivers | 13,202 | 3,324 | ..... | 0.00 |
| Ocean Shore of Rhode Island | 1,151 | 287 | 1,151 | 100.00 |
| Narragansett Bay and tributaries | 15,836 | 4,071 | 2,163 | 12.17 |
| Buzzards Bay and Vineyard Sound | 3,385 | 834 | 3,385 | 100.00 |
| Cape Cod and Massachusetts bays | 33,082 | 1,468 | 33,082 | 100.00 |
| Casco Bay | 64,490 | 3,580 | 64,490 | 100.00 |
| Kennebec River and tributaries | 290,122 | 26,357 | 55,987 | 19.30 |
| Penobscot and other Maine rivers | 12,126 | 941 | 6,000 | 49.48 |
| Total | 13,067,469 | 1,651,376 | 6,252,464 | 47.85 |

WASHINGTON, D. C.

# THE GREEN TURTLE, AND THE POSSIBILITIES OF ITS PROTECTION AND CONSEQUENT INCREASE ON THE FLORIDA COAST.

By RALPH M. MUNROE.

Early travelers on the tropical coasts of America made much mention of the abundance of turtles which were to be seen in the waters at all times and on the beaches in the spring season engaged in laying their eggs. How many of these belonged to the species *Chelonia mydas* is mere conjecture, for, aside from the tables of the rich and the cabins of the mariner, to the latter of which it often came as a Godsend in times of hunger and scurvy, it was comparatively unknown, and as other species were edible and somewhat similar in appearance, the old chroniclers put them all under the one head of turtle. As a matter of fact, the loggerhead (*Thalassochelys caretta*), common now on our coast, when not oversized and when properly butchered and cooked, is not to be despised by a man even not hungry, and so also the hawksbill (*Eretmochelys imbricata*), from which comes the tortoise shell of commerce.

With the advent of steam vessels, penetrating as they do the labyrinths of the West Indian islands and adjacent coasts, enabling the perishable tropical products to be transported in safety, the green turtle has become a more common food and less of a luxury in our seaboard cities, and, as most people take kindly to it, the demand has increased with the usual result in connection with natural products, a growing scarcity and higher prices. Being, as it is, a nutritious delicacy, it is quite time that its habits, production, and methods of capture should be looked into before its enforced classification with the extinct reptiles, even if this should be an event far distant; and it might be well worth our time and attention to reduce, by cultivation and protection, the present rather prohibitive price of a valuable food.

As is the case with very much of marine life, but little is known as to the habits of the green turtle. Its food is a marine grass growing on the bottoms of lagoons and bays more or less shallow. It mates on the Florida coast in the month of May, or thereabouts, the females with eggs, except in rare cases, at once disappearing from these waters, and, until recently, going no one knew where, but it may now be asserted that their hatching-grounds are the beaches of various isolated islands off Central America or the Bahama banks. How this migration is accomplished across the Gulf Stream for hundreds of miles is past comprehension. As high as four hatches of eggs, containing from 130 to 180 each, are believed to be laid by one female during the months of June, July, and August, and the process is not repeated until an interval of one or two years has elapsed. Incubation takes from ten to twelve weeks. We have little information as to where the young that escape the gulls and other birds on the beach, the fish and sharks, pass their time on entering the water again like their

elders, until we occasionally see them in what is called the chicken stage of growth, so called from the resemblance of their flesh to that of the feathered barnyard favorite.

The foregoing few items are about all that is known as to habits, but sufficient seems to be established to form a reasonable hypothesis that much might be done toward protecting the young and possibly caring for them until of marketable size.

At present the probabilities are that but an exceedingly small number survive the first week of existence, as low, perhaps, as 2 to 3 per cent. To prevent this loss may or may not be an extremely simple problem, depending on whether turtles will mate and deposit eggs in suitably inclosed feeding-grounds, or if the female alone, in a condition to lay (these average about 20 per cent of the catch in May and June on one reef at present), will carry out her maternal functions in captivity. If these two points are negative, then is it feasible to import the eggs from the foreign depositories, considering the expense and possible complications as to ownership? And, lastly, would our supposed food areas prove sufficient and suitable? The latter point, I think, can be favorably answered, as our lagoons have long been known as feeding-places for the smaller turtles, and it is fair to suppose that the younger ones could find, in the same localities, a diet congenial to them; therefore, if no serious obstacles were found in their production, the subsequent existence up to the age of taking care of themselves seems assured, and at a trifling cost, after once hatched.

The statistics in regard to this branch of our fisheries are meager and of little value. The few at hand seem to show that the average catch of mature turtles along the reef by nets in the past twenty years seems to be but slightly diminished. When the fleet is augmented by boats and men, the catch per boat decreases and vice versa, but it is very evident, from personal observation covering the same period, that our feeding-grounds or inshore resorts for the smaller and more valuable sizes have become almost depleted. This results apparently not from excessive fishing, but probably from the gradual capture on the outer grounds of females which occasionally depart from the instinct of going to remote places for incubation and lay their eggs on home shores; for it is hardly possible that the young from the distant hatcheries across the Gulf Stream should find their way back until fully matured and able to cope with their natural enemies in transit.

For verification of some mooted points, and for additional information on others, I am indebted to Mr. B. Vincent Archer, a lifelong fisher and close observer of the green turtle in these waters.

COCOANUT GROVE, FLORIDA.

# SOME FACTORS IN THE OYSTER PROBLEM.

By H. F. MOORE,
*Assistant, United States Fish Commission.*

The annual product of the oyster-beds of the United States is estimated to be worth $17,000,000, approximately one-third of the entire yearly value of our fisheries. Geographically this income is very unequally distributed, the eight maritime States between Cape Cod and Cape Henry receiving 90 per cent and the same number of States south of Cape Henry, notwithstanding their greater coast line, but 7 per cent.

While there are good economic reasons why the oyster yield from Virginia northward should be greater than from North Carolina southward, it may well be doubted if there be sufficient reason for the great discrepancy that now exists in the production of the two regions. The northern beds are, generally speaking, in the midst of our densest population and in the vicinity of our greatest cities. About 60 per cent of our population dwells in the compact area lying north of North Carolina and Tennessee and east of the Mississippi River. Such populous cities as Boston, New York, Philadelphia, Baltimore, and Washington are within a few hours travel of the beds, and the cities on the Great Lakes and in the interior of the middle West are scarcely a day's journey removed. Oysters are more commonly consumed in such places rather than in more sparsely settled regions. In rural districts the oyster is looked upon as a luxury rarely to be enjoyed, but in the cities and towns of the East they are a familiar article of diet even among the poor.

So far, then, as the near-by demand is concerned, the Northern oystermen are incomparably more favored than their Southern brethren, but certain advantages which the South possesses should to some extent offset this and enable the Southern growers to obtain more equitable distribution of the business and its accruing profits. It has been to some extent demonstrated that the distance of the Southern beds from the Northern market is not an insuperable bar to profitable competition, but, granting that the oysters from the Gulf coast can not compete in the markets of the Atlantic seaboard north of the Chesapeake, there still remains a large field which may be entered upon with advantage.

Dealing with air-line distances, Baltimore is nearly 400 miles nearer Chicago than is Mobile, the nearest important city on the Gulf coast; but westward of the Mississippi the Gulf States can compete on equal or superior terms, so far as distance is concerned, with any of the great oyster markets of the East. Geographically, therefore, they are more favorably situated with regard to 80 per cent of our territory and 40 per cent of our population than are the States of the North Atlantic coast. As many of you are aware, oysters have for some years been shipped from Gulf ports to Chicago and other trans-Appalachian cities, and dealers in several places are carrying on trade with the entire region west of the Mississippi, even as far as the shores of the Pacific, and there appears to be no sufficient economic reason why this trade should not be vastly increased.

After speaking of the arrest in the development of the canning industry at Apalachicola, Lieutenant Swift, in his excellent report upon that region, comments as follows:

> That the canning business can not be carried on to any great extent for any length of time is due to the fact that the supply of oysters is insufficient to supply the demand, notwithstanding that the packers have used every means they could to preserve the oyster-beds by refusing to take oysters under proper size, or out of season, or not properly culled, as well as alternating the use of different beds each season.

This is perhaps an extreme case, yet sooner or later, corresponding with the wisdom with which the oyster question is administered, there must result a similar depreciation of the natural beds along the entire coast. I can see no hope of the continued productiveness of our natural beds if they are made to bear the brunt of the yearly increasing demand.

How to forestall the destruction of the natural oyster-reefs and how in a measure to prevent it by lessening the demands made upon them are the questions with which this paper sets out to deal. Those who have studied the problem are a unit in the belief that the solution lies in the general adoption of oyster-culture under private ownership and as a result of private enterprise. Government can do but little. Wise laws rigidly and judiciously enforced can stimulate private ventures and retard reckless waste of the public possessions, but our oyster-beds can never be repopulated by the methods which have in many cases proven so beneficial in restocking our streams with food and game fish. It is not my purpose to deal here with the methods and details of oyster-culture, as these subjects have been recently treated of in the publications of the U. S. Fish Commission,[1] but rather in a general way to point out the conditions which make for success and to consider in an equally general manner the extent to which those conditions are fulfilled on the Gulf coast from Florida to Texas.

The Gulf States present many physical and biological characters which render them especially favorable to oyster-culture, and they also present some serious drawbacks. In determining the qualifications of any given region six important factors have to be considered—(1) density of the water, (2) temperature of the water, (3) character and consistency of the bottom, (4) the quantity of oyster food, (5) the presence or absence of enemies, and (6) the character of the legislation and the success with which it is enforced. Each of these factors with its cognates will be considered in turn.

## DENSITY OF WATER.

If a chart of the oyster-grounds of the Atlantic and Gulf seaboards were prepared it would show that the oyster is confined almost exclusively to bays, sounds, and estuaries, and that it is never found in places remote from inflowing streams. On the other hand, it is sooner or later killed when exposed to the fresh water or that which is nearly fresh, and it is therefore only where the fresh and salt waters blend that it is able to establish itself and thrive. It is customary to measure the saliuity of sea water by weight, an equivalent bulk of distilled water being accepted as the unit of comparison. So expressed, the best conditions of salinity for our eastern oysters are met when the density measures between 1.009 and 1.020. Oysters will live indefinitely in a density 4 degrees below or 2 degrees above the limit stated, but they then rarely or never attain their best conditions of shape, flavor, and general excellence. Prolonged

[1] See Report U. S. Fish Commission 1897, pp. 263–340.

xposure to a density of less than 1.005 or more than 1.022, if not fatal to the individ-als, is at least fatal to the species, as young are not produced to take the place of the ld ones which are dying off.

In many places where the salinity is favorable during a large part of the year it appens that at certain seasons a heavy influx of fresh water produces a temporary eduction below the desired minimum. This appears to be particularly liable to occur n the Gulf coast, where many great streams and innumerable small ones become wollen by the rains and discharge large quantities of fresh water close to the oyster-eds. Two facts, however, tend to mitigate the evil which might result. In the first lace the oyster is able to tightly close its shell when subjected to objectionable onditions, and thereby the fresh water may be for a time excluded, and Professor Vashburn has recently shown that they will live for upward of ten days in the water f running brooks. Then, too, the fresh water, being lighter than the salt or brackish, ends to spread over the surface of the bays into which it is discharged, and it is sually found that the bottom density is greater than the surface density, even after ong-continued freshets. The changes are therefore more gradual and less radical han if the salt water were driven out before the fresh, and the oyster finds conditions ore favorable at bottom than it would be subjected to if it were a surface-dwelling rganism. In selecting planting-grounds the question of liability to the influence of reshets should always be given consideration, as disaster may result from its neglect.

### TEMPERATURE OF THE WATER.

Adult oysters are not ordinarily adversely affected by temperatures ranging etween the freezing point and 90° F. Those upon flats exposed at low water are ften frozen during the winter and subjected to the high temperatures of the direct ays of the summer sun, and yet many of them live to a ripe old age measured by the pan of an oyster's life. During the spawning season, however, a temperature too low r too high, or changes too sudden and too violent, will either kill the spat or prevent pawning altogether. In the Long Island and Chesapeake regions cold rains and eriods of low thermometer are not infrequent in summer, and multitudes of oysters n their swimming stage end their career in sudden adversity. On the Gulf coast uch fatalities are of less frequent occurrence, and the probabilities of obtaining a et, other things being equal, is correspondingly enhanced.

### CHARACTER OF THE BOTTOM.

To be suitable for oyster-culture the bottom should be of such consistency as will prevent the oysters becoming engulfed in the mud or covered by shifting sands or ooze. The several surveys that have been made of the Gulf coast by the Fish Commission indicate that suitable bottom, unoccupied by a natural growth of oysters, may be found with but little effort. These sections of our coast, however, appear to be rather more liable than the northern oyster-grounds to shiftings of the bottom by stormy seas, and the prospective oyster-grower should not be misled by deceptive appearances, as a loose sand in shallow water exposed to heavy or even moderate wave action may in a short time change its location in a manner disastrous to the planter. With large areas of suitable bottom open to occupation, it is not necessary o point out to the Gulf coast oyster-grower the means by which his Connecticut rother has made available to his purposes many thousand acres of bottom by nature holly unadapted to the oyster.

## ABUNDANCE OF FOOD.

That the nature of the food supply is a consideration of the utmost importance requires no demonstration. The conditions which make an abundant food supply are complex, depending upon density, temperature, and especially the supply of inorganic materials in solution in the water. The bulk of the oyster food consists of diatoms, which, although endowed with powers of locomotion, are nevertheless plants, and acquire their nourishment from the same class of substances as do the common plants about us. It is true that they have no roots penetrating the soil in search of saline solutions, and they spread no broad foliage in quest of atmospheric oxygen and carbon dioxide, but the whole plant is bathed in the nutritive sea water, from which they receive their supply of liquid and gaseous food. If the water be impoverished of salts the same adverse conditions obtain as in barren and exhausted fields and the growth of plant life is in the same manner diminished. Now, how is the Gulf coast situated as regards this inorganic material, indirectly, but no less imperatively, necessary to the growth of the oyster? Along the entire shore line there are numerous streams of all sizes which bring down mineral matter derived from the soil and nitrogenous substances from the decomposition of the rank vegetation of marshes, swamps, and fertile fields. Some of these materials are in solution, and at once available for conversion into oyster food through the medium of the microscopic plants already mentioned, but a large quantity is held merely in suspension, to be deposited on contact with salt water and slowly passed into solution through the lapse of time. With the abundance of food thus furnished, and nurtured by the warmth of semi-tropical waters, it is not surprising that microscopic plant life should flourish.

The rate of growth of the oyster depends upon the rate with which it is supplied with food. When well fed its growth is rapid; when poorly fed its increase is slow. In one locality an oyster may reach a growth of 6 inches in two years, and in another place the same size is not attained under four or five years. On some of the more profitable beds in Long Island Sound the latter is the case, while last summer, in Plaquemines Parish, Louisiana, I saw oysters 6 inches long which, from known data, could not have been over 23 months old and may have been slightly less, and there are doubtless many places on the Gulf coast where the growth is equally rapid. This rapidity of maturation is an important matter to the oyster-culturist. He is able to receive quicker and greater returns for a given area and a given investment of capital, and his beds are less liable to disaster and recuperate more rapidly than if the growth be slow. Large oysters are less readily covered by deposits of mud and sand than smaller ones, and are more rarely destroyed by enemies, the latter usually proving more destructive before the shells have become thick and the adductor muscle strong. The drill is comparatively harmless to an oyster after it reaches a length of 3 inches, and the starfish opens and the drumfish crushes large oysters with much less facility than small ones. It follows that the mortality on a bed of well-grown oysters is less than when they are small, and the more rapid the growth the less the death rate from extrinsic agencies. The value which an oyster possesses in the market is dependent largely upon its fatness and flavor, and both of these are principally and primarily dependent upon its food. Oysters may reach a large size, yet not become fit for the market, and in certain parts of the Atlantic coast the difficulty has been keenly felt by those engaged in oyster-culture. The United States Fish Commission is now experimenting with a view to enable planters to fatten their oysters at will, but defi-

nite results have not yet been reached. It may be stated, in passing, that these experiments have nothing in common with the pernicious process of plumping through the osmotic influences of fresh or brackish water.

### ENEMIES.

The Gulf coast is fortunate in its comparative immunity from enemies of the oyster. Two of the most destructive inhabitants of oyster-beds in the North, the starfish and drill, are practically harmless in the South, and to those familiar with the vast amount of money and energy annually expended in protecting the beds of Long Island this fact is very significant. In six years the vessels of one deep-water planter caught nearly 10,000 bushels of starfish, and another in a single year is said to have expended $90,000 in protecting his beds from the same pest. There are, however, certain enemies on the Gulf coast which do more or less harm. The drumfish is apparently more destructive than in the North, and the sheepshead is said to also do considerable harm. Should either of these fish prove troublesome it would be quite feasible, as has been demonstrated on the Pacific coast, to protect many of the planted beds by stockades or fences. The economic practicability of the plan, however, would be conditioned by the price of oysters and the location of the beds which it is sought to protect. The conch and a somewhat allied gasteropod, the crown shell, known to naturalists as *Melongena corona*, are said to cause more or less harm to oysters in the Gulf. Mr. Joseph Wilcox, of Philadelphia, says in regard to the latter that they are able to insert their long tongues or proboscides between the valves of the oyster and then leisurely destroy it. He further says that upon one occasion he picked up on the west coast of Florida a cluster of oysters with 20 *Melongenas* attached. Owing to the comparatively large size of these forms it is probable that by exercising care to destroy the animals and their egg capsules whenever found much could be done toward securing some immunity from their inroads.

Summing up, we find that the Gulf coast possesses both advantageous and disadvantageous features from the oyster-grower's point of view. The advantages are principally biological; the disadvantages, economical. The physical conditions are mainly favorable, but occasionally disastrous. The temperature and density are both suitable over a large part of the region, enemies are comparatively few, food is abundant, and the growth and recuperation of the beds rapid; labor is cheap and the weather is less likely to interfere with operations than in the North, where oystermen are often compelled to work in intense cold and on boisterous seas. The disadvantages have principally to do with the freshets and crevasses which at certain seasons are liable to lower the density and deposit sediment upon the oysters, the occasional severe storms and tidal waves which tear up and destroy the beds, and finally the distance from the centers of population and the principal markets of the country.

### LEGISLATION AND ITS ENFORCEMENT.

In most of the maritime States the statute books are burdened with lengthy oyster laws, and a large part of the time and energy of the legislative bodies are occupied in the discussion of these laws and their enforcement. In all of these laws and in most of the discussions the close season is an important factor by which it is hoped that the natural beds may be preserved from destruction. It is invariably designed to prevent the capture of the oyster during the breeding season on the hypothesis that when

taken at that time there results not only the destruction of the adult but also of the progeny which that adult is capable of producing, and it never occurs to the advocates of this form of legislation that the same objection applies to the capture of an oyster at any other time. If the oyster were more easily captured during the spawning season, as are certain species of fishes, or if it were a timid creature fleeing from alarm and easily driven away, or if it cared for its young after the manner of the higher animals, there would be perhaps some warrant for the present belief in the all-sufficiency of the close season as a protective measure. But the oyster does none of these things; it stays where it first lodges and there passively awaits such fate as may be in store for it, doing nothing of its own volition, either to defer or expedite its capture.

Bearing these facts in mind, let us examine the effect of the close season upon two hypothetical beds, one of which is closed during the period when the oyster is spawning, the other when it is not. We will suppose, for the sake of definiteness, that each of these beds contains 10,000 bushels of oysters; that spawning takes place only during the six months between the 1st of April and the 1st of October; that the oystermen have the skill, industry, and purpose to remove every oyster during a working period of six months, and finally that the dead shells are culled out and returned to the beds. Let us first consider the case of the bed which is closed in the usual manner during the spawning season. The oystermen will begin on the 1st of October and labor unceasingly until the 1st of April, when, *ex hypothesi*, there will not be a single oyster left to spawn and the reproductive capacity of the beds will be zero. Compare with this the bed which is closed during the six months when the oyster is not spawning. At the beginning of reproductive activity the bed is intact; it contains 10,000 bushels of oysters, each, we will say, capable of producing its kind. At the end of the six months, as in the former case, not an adult oyster is left, but the condition of the two beds is not otherwise comparable. In the first place not an oyster has spawned; in the second case, supposing the daily catch to be approximately constant, one-half of the spawn has been given opportunity for discharge and a considerable portion of the spat should have attached itself to the culled shells and other material returned to the bed. In the one case, if the bed be isolated, absolute extermination has been accomplished; in the other case the bed still contains the elements of recuperation. In practice, of course, the extreme conditions mentioned never obtain, but the principle is the same whether the oysters be taken in whole or in part.

In practice also, where some oysters always remain on the beds, even after the most thorough working economically possible, the close season has a utility not yet touched upon. In its early attached stages the oyster is not the hardy, heavily armored animal that we see in the market. Its shell is thin and fragile as an eggshell, and closely adherent to the foreign body which furnishes its place of attachment. Tongs, and especially dredges, however carefully handled, must crush them by multitudes, and the impact of the oysters against one another as they are thrown into the boat costs the lives of many more. A large proportion of the young spat is often attached to marketable oysters, and however well-intentioned the oysterman may be in his efforts to comply with the culling law, it is quite impossible to detach the spat without killing it. When the close season ends immediately upon the cessation of spawning a very large proportion of even the earliest set is subject to the perils pointed out. If the young oysters could be protected until such times as the shells

become strong enough to withstand the mechanical effect of capture and culling, a distinct advance would be made in the administration of our natural reefs. The prolongation of the close season for a period of six weeks or two months would, in a region of rapid growth, permit the shells to attain a strength sufficient to prevent crushing, and a size that would allow some of them to be culled from the marketable stock. Economic objections may be well offered to this proposition, for in many cases it would cut off the fisheries at a time when the financial inducements are large. It is a matter, however, worthy of consideration by those engaged in framing oyster laws; and I believe that in some localities a close season beginning, say, two months after the commencement of spawning and extending two months beyond its cessation will have a better result than an equal period adjusted to the spawning season only.

Another plan would close the beds, each in rotation, for a term of years sufficient to allow them to recuperate from the effects of the fisheries. Doubtless this would be the most efficient type of close season, but it presents alternative difficulties in administration. If the areas closed be large, those deriving their living therefrom must either travel long distances to prosecute their calling or temporarily abandon it; if, on the contrary, the areas be small and correspondingly numerous, the regulations would require a large oyster police for their enforcement. Another plan, on our extensive oyster-grounds still more impracticable than the preceding, is to limit absolutely the number of oysters to be taken from the beds. This has been the only regulation able to protect the oysters in certain parts of France and Germany; but it involves elaborate governmental machinery, officers for administration, guards for protection, and scientific men for determining the condition of the beds and estimating the number of oysters which may safely be removed. Such elaborate measures are possible where the beds are few in number and limited in extent, but are entirely inapplicable to the conditions prevailing in our waters.

Another almost universal feature of oyster regulation—and, in my opinion, a more important one than the close season—is the requirement of culling upon the beds from which the oysters are taken. Most States have in this respect good laws, but unfortunately they are often neither enforced nor voluntarily observed. It is not difficult to prevent young oysters from being put upon the market, and there is but little temptation to so dispose of them if the limit be fixed, as is common, at 2½ inches; but as seed such oysters may be sold without the limits of their native region, and to its great detriment. Then also, when the beds are distant from the places of sale, there is always a strong temptation for the oysterman to save time by culling them on the way to market. In some cases this may produce no harm, and may even result in the establishment of new beds, but in general the practice is to be deprecated from the probability that young oysters thus culled would fall upon soft or shifting bottoms, or be otherwise placed under adverse conditions.

It is self-evident that if the young oysters and the objects to which they may become attached are systematically and persistently removed, there must follow a scarcity of adults, and in time economic if not biological extinction of the beds will result. In due course such beds may, and often do, become restored and regenerated, but the process is usually slow as compared with the demands of our markets. I regard it as a misfortune in some respects that the vast spawning capacity of the oyster is so generally understood. The knowledge that the female emits annually millions of eggs has begotten an impression that the beds need no protection, and

that when they fail it is due to starfish or drills or mud or any one of a dozen other factors, rather than to improvident management. It must be remembered that but a modicum of these eggs reach maturity, else our bays and estuaries would long ere this have been converted into beds of limestone. Broadly speaking, nature provides for the perpetuation of her species either by means of a few eggs well protected, or many eggs left, as it were, to chance. To the biologist the simple fact that the oyster is so prodigiously prolific is ample indication that its existence from the egg is a precarious one. Its life is a constant passive struggle with physical conditions, its enemies, and its brethren, and fortunate indeed is the oyster region where, of every million eggs produced, one reaches marketable dimensions.

An important, in fact an essential, element in the oyster's salvation is the presence of a solid body to which to affix itself when it is ready to settle down at the conclusion of its free-swimming condition. It is then so exceedingly minute that a film of mud not thicker than a sheet of paper is sufficient to stifle it. It will attach itself to almost anything fairly free from sediment, but on the oyster-beds such objects are almost exclusively living oysters or dead shells. A depleted bed differs from a vigorous one in two particulars: In the scarcity and scattered distribution of spawning individuals, and, perhaps more disastrously, in the paucity of suitable places of attachment for the young. From both causes the reproductive capacity of the bed is reduced, but were the culled and dead shells returned to the bed both conditions would be ameliorated. Under any system, however, even with good culling laws and close seasons, it is hopeless to expect to supply the demand for any length of time wholly from the natural beds. The only way in which to prevent their ultimate depletion is to supply our markets largely from other sources; that is to say, we must resort extensively to oyster-culture; and the character of legislation and the success with which it is enforced are determining factors in the success or failure of the undertaking.

Liberal measures must be adopted, and opportunities, if not inducements, must be offered. Private ownership must be established, and more especially the rights of property in the planted beds must be vigorously enforced. More than this the State can not well do. The methods of fish-culture are not now, and probably never will be, available in propagating the oyster. Fish-culture in many of its phases is a legitimate and proper function of government, as all members of the community, whether they be catchers or consumers of fish, partake of its benefits. In most cases, owing to the nomadic character of the species propagated, private enterprise has no inducements for engaging in it except those of philanthropy. Not so with oyster-planting as at present practiced, for only he who sows reaps. Dr. Ryder once said "Oysters are like potatoes, they stay where they are planted." All that the planter need ask of the Government is to be placed on an equal footing with every other citizen; to be permitted to acquire, without prejudice to others, property adapted to his calling, and to be protected in his rights after acquirement.

With this understanding the first question to arise is how and where he may obtain such property. In some cases he may go into the markets and purchase land conveying to him the ownership of coves or salt ponds, but such cases are rare and oyster-culture so confined would be unimportant indeed. Again, he might buy land on tide water and excavate ponds, but oyster-culture has not reached a stage where such methods would in general prove profitable. The only course left him, then, is

occupy tide lands, which in most cases are held by the State. To enable him to do this legislation is necessary, and the lawmakers at once ask, What shall be the character of his tenure and how is it to be acquired? Shall he be granted a leasehold for a term of years or shall he be permitted to occupy it in perpetuity, the State retaining only the right of taxation and its related powers? Whichever policy be adopted no impediments should be unnecessarily introduced in the way of a *bona fide* planter. The returns from oyster-culture are often large, though not exorbitant, but the risks are many and disaster not infrequent. Those who undertake the work and thus add to the State's resources should be treated with every consideration to which their courage, enterprise, and industry entitle them.

The tide lands in most cases are worthless and doubtless will ever remain so for purposes other than oyster and sponge culture, and they can be occupied without prejudice to any other business whatever. The policy of the State should be to encourage their occupation, and in this connection a lesson may be learned from the liberal policy which has induced the rapid settlement of our vast agricultural estate. The logic of our history would dictate the throwing of the tide lands open for occupation, yet in how many States are the laws, and more especially public opinion, practically, if not intentionally, prohibitive? A policy far different from that in land above tides is supposed to be justifiable in dealing with that portion of the State's domain lying beneath the sea. There is reluctance to part with the tide lands, and it is thought preferable to allow them to lie barren rather than to permit individuals to acquire permanent possession. There can be no doubt but that the best results are to be obtained when the oyster-grower holds his lands in fee simple. Under proper management the bottom becomes more favorable the longer it is cultivated. It yearly becomes firmer and freer from extraneous organisms and the miscellaneous rubbish which accumulates in shore waters, and the man who improves it is the one who should reap the benefits.

It is to the advantage of the State to interest a thrifty class of citizens in the subject, and such persons are the very ones who will hold aloof if they are to be subjected to the frequent possibility, if not probability, of dispossession. The land should be granted under the freest possible terms. If revenue be desired it should be derived from the subsequent increase in taxable value rather than from sales or rentals. The primary function of government is the welfare of its citizens, and, contrary to the apparent standpoint of some legislators, taxation is but an incident which the first consideration renders necessary. The first cost of the oyster-lands granted by the State should be little more than enough to defray the expenses of survey and registry, and not such as would debar those of small means from partaking of the benefits. In Connecticut the State lands are sold for $1 per acre and the additional payment of 10 cents per acre, the estimated cost of surveying and recording, when the tract applied for is not, in the opinion of the shellfish commissioners, of an unreasonable extent. Under these provisions over 71,000 acres, owned by almost 300 persons and giving employment to thousands, were under culture in 1896, the amount of material deposited thereon in planting and improving the beds being over 8,000,000 bushels. Other States are still more liberal, permitting the occupation of oyster lands under provisions practically similar to the United States homestead laws. But Connecticut has so far been easily first in the development of oystering in naturally unproductive waters. This is largely due to her advantageous geographical position with regard to the mar-

kets, but it can also be attributed in part to the natural industry and enterprise of her citizens and to the enlightened public opinion which places planted oysters on a par with other property and respects the right of the planter to reap the fruits of his labors.

Of enterprise and industry Connecticut has no monopoly, but unfortunately there are many parts of our seaboard where the oyster-planter is regarded as the usurper of the common rights to the fisheries and his legal rights are interfered with by an adverse public opinion. This is one of the greatest difficulties with which he has to contend. Theft of property beneath the tide is palliated by some as an act of retributory justice against a common enemy, and men will steal oysters who would scorn to enter their neighbor's poultry-house. This peculiar moral obliquity is rooted in ignorance and must be combated by education, supplemented by more than occasional salutary castigations from the strong arm of the law.

*Summarizing:* Those who wish to perpetuate and extend our oyster wealth should procure a rational culling law rigidly and intelligently enforced; the close season should be at such time and of such duration as will protect, not so much the spawning oysters, but the delicate spat during the period when it is especially susceptible to injury from the ordinary working of the beds; public opinion must be formed to regard oyster-planting in its true light, as a benefit to the whole community; liberal laws must foster and encourage the occupation of the tide lands not natural oyster-beds; the oyster-planter should have the same treatment as the cotton-planter, sugar-planter, or the market-gardener, with liberty to hold or dispose of his property as he pleases, paying a just proportion of the taxes and no more.

WASHINGTON, D. C.

# THE OYSTER-GROUNDS OF THE WEST FLORIDA COAST: THEIR EXTENT, CONDITION, AND PECULIARITIES.

By FRANKLIN SWIFT, U. S. Navy,
*Commanding United States Fish Commission Steamer Fish Hawk.*

The oyster-grounds of the west coast of Florida extend the whole length of the coast. Oysters are found growing in great abundance in the waters between the mainland and keys, and are particularly noticeable clinging to the roots of the mangroves which fringe the mainland and keys along the southern coast. These oysters of the extreme southern waters of Florida are mostly of the raccoon type and are not very palatable, being "coppery" and of poor quality.

The oyster regions of the central and northern part of the coast are found in the many inclosed bodies of water, and are located in the vicinity of the mouths of rivers in waters where the density is affected by the fresh water of such streams. The question of density is of prime importance in connection with oyster growth, and edible oysters can only grow where the salt water is influenced by that of less density. If the normal sea water is taken at 1.026, then 1.016 represents the most favorable density for oyster life. However, the densities in which oysters seem to thrive cover a great range, and in nearly all beds oysters are subjected to the extreme ranges between the different stages of the tide. In freshets oyster-beds are sometimes destroyed, owing to the long-continued prevalence of fresh water.

The oysters of the west coast of Florida are all found in very shoal water compared to those found in the Central and Northern States, and a glance at the chart will show the comparative shallowness of all the inclosed bodies of water along the west coast. Marketable oysters are taken in water from 10 feet to 1 foot in depth, and in less than 1 foot and above low-water mark are found the raccoon oysters. Large beds of the latter type lie exposed at low water and thrive, even in their exposure to the hot sun or cold air, during the low ranges of the tide. The shells of these oysters are long and pointed quite sharply, and the oysters are more flat than those of the marketable type. These oysters, culled and transplanted, often do well on cultivated grounds.

The bottoms of the coast waters which contain oysters are almost invariably very soft mud, and it appears remarkable how the solid beds are ever formed on such yielding material. The mud is often of the nature of ooze, and a pole may be thrust down many feet before finding any resisting strata. An examination with a steel-pointed probe usually shows the following strata on the beds: The crust of the bed, composed of shells to a depth of 2 or 3 feet; a layer of soft sand, extending down about 5 feet, and then hard sand or hard mud. The beds are almost entirely long and narrow in extent, and rise precipitately from the muddy bottom, forming reefs dangerous to navigation, as no warning of their presence is given by the soundings. On these reefs there is usually 2 or 3 feet of water at low water. In some localities the oysters are scattered over the bottom, forming beds like the northern beds, but it may be said generally that the oysters of the natural beds grow on the densely packed reefs before mentioned.

In the oyster regions of Apalachicola Bay the survey made in the winter of 1895–96 by the *Fish Hawk's* party showed the condition of the beds with great detail. The oysters there were found in clusters, and ranged in size from very small to full size in each cluster, the crowding of the oysters in the clusters being a serious retardation to their growth. In addition, the whole mass was invariably thickly covered with mussels, so that without doubt great good would result in breaking up and separating the oysters of the clusters. In the Apalachicola work the average number of oysters to the square yard was taken on the different beds, with a view to forming a comparison at a future survey, and thus determine the increase or decrease of each bed.

The questions of temperature and food supply are very important; the former affects the spawning season directly, and the latter depends to a great degree on the currents. Generally speaking, the spawning season extends from the middle of April to the middle of July, but these limits of time vary with the temperature to a considerable degree, a cool spring causing a late spawning season. However, it is probable that in the waters under consideration the oysters spawn to a greater or less degree all the year around. This is evidenced by the fact that the spat is observed in all stages of development during the year. It is generally considered that oysters reach a spawning age at the end of three or four years.

The current concerns the food supply materially; the bottoms most favorable to oyster growth, as those over which there is gentle flow, changing in direction as the tide changes from ebb to flood. The long, narrow reefs which form the beds are almost invariably at right angles to the direction of flow of the current, and the banking up of the water caused by its meeting an obstruction in the form of the bed gives it an increased velocity, so that usually the locality of the bed is at once shown by the tide rip. Of course, at slack water no such material aid is given in finding the beds. It is a singular fact that almost without exception the beds are crescent-shaped, with their concave surfaces all on the same side of the areas of the beds.

The enemies of the Florida oysters are few in number. The starfish, the pest of oysters in Long Island Sound and other localities, is rarely found, and the loss from injury by drills is very small. Parasitic growths, in the form of mussels and barnacles, are injurious; but they may hardly be classed as enemies, as their harmful effects are indirect. It may be said that the Florida oysters are singularly free from exposure to enemies that oysters of other sections are subjected to.

The three great natural conditions that work destruction to the beds are the freezes, hurricanes, and freshets that occasionally occur, and the first two take place principally in the northern sections of the coast. The cause of the deterioration of the beds other than from natural sources is almost invariably due to overworking. The demand is too great for the supply, and the beds are worked until they no longer yield profitable results, and usually until they are so depleted that years are required for them to recuperate. Add to these causes the facts that the oystermen are so shortsighted that they pay little attention, as a rule, to the laws regarding culling and taking undersized oysters, and it can readily be seen that there is a small chance for the productiveness of the beds to increase. Fortunately, dredging is prohibited by law, and it is the one law that is usually observed, and only because the use of dredges would be immediately noticed and complained of. Again, dredging as practiced in the North could not easily be carried on advantageously, on account of the shoal water.

As measures for the improvement of the beds, I would recommend that no oysters be taken from April 15 to October 15; that the law now in force regarding the culling

of oysters on the grounds and the law regarding the taking of undersized oysters be strictly enforced. Oystermen as a rule pay little attention to the laws that affect them so materially, but it is noticeable that the more enlightened men of larger interests, as, for example, the canners, are much in favor of having proper laws and having them enforced. The fact of such intelligent men being anxious for the enforcement of the laws seems a strong argument in favor of such enforcement.

All that has been said applies to the natural beds. Oyster cultivation has become a great industry in the Northern and Central States, and is now beginning to extend to the Southern coasts. Florida has been far behindhand in this industry, but it is hoped that the great importance of it can be proved to those interested, and that in the near future Florida shall have her share of the great sums brought into the State treasuries of some of the States from taxes alone, not to mention the advantages accruing to individuals. The United States Fish Commission has already done much to encourage the cultivation of oysters in Florida. The section of the coast about Apalachicola Bay was surveyed, as already mentioned, and a chart showing the exact delineations of the natural beds and the areas of good planting-grounds made. By means of this chart any person of average intelligence can locate himself on the best ground possible for planting. Having such knowledge, a mere scattering over the bottom of shell to form a cultch to which the spat may attach itself, with the necessary overhauling from time to time, would result in profitable beds. Or, again, seed may be taken from the best natural beds, as it is known that the beds differ very materially. In connection with the cultivation of oysters the United States Fish Commission's Manual[1] on the subject will furnish the best possible suggestions, and all those new to the business will do well to study it.

All natural conditions are favorable to the planter, and as for the seed, as already mentioned, the beds vary greatly even in the same locality, but there are beds all along the coast where the oysters are of the very best quality and compare favorably with the finest-flavored oysters of the most famous d stricts on the Atlantic seaboard.

The one great impediment to oyster cultivation in Florida is that the laws protecting planters are not enforced. There are instances where men have been obliged to give up the work of cultivation on account of the lack of protection. The laws are perhaps sufficient, but it is imperative that they be enforced. First of all, the oystermen must be brought to a realization of the fact that the protection of oyster cultivation does not in any way infringe upon their rights, and that on the contrary it is directly for their best interests. All have equal rights and any man having sufficient thrift and energy may without doubt better his condition by undertaking the cultivation of oysters and uniting with others to respect the laws. The moral sentiment among oystermen is not in favor of protection, and this is due principally to their misunderstanding the subject. The law makes a distinction between cultivated beds and natural beds and relates wholly to the cultivated beds, but oystermen think that any protection given to the planters is of the nature of a monopoly and is an encroachment on their rights. Of course such is not the case, as the laws protecting planters do not in any way interfere with oystering as now carried on on the natural beds. All the oyster cultivation would be carried on away from the natural beds, and in some cases in localities entirely remote from them.

WASHINGTON, D. C.

[1] Oysters and Methods of Oyster-Culture. By H. F. Moore. Report U. S. Fish Commission for 1897, pp. 263–340.

# THE OYSTERS AND OYSTER-BEDS OF FLORIDA.

By JOHN G. RUGE.

To treat this subject properly one should be prepared to consider it in all its aspects, relatively and otherwise. I do not offer you anything new, and I even confess plagiarism, yet hope it is so shaped as to engage your attention.

I may observe that oysters of many species are found nearly all over the world: the British Isles, the Mediterranean, Holland, Belgium, Germany, Denmark, Norway, and part of Russia, Australia, China; nearly all parts of the eastern coast of America from Canada to Cape Horn; also the northwest coast of the American continent. Oysters are plentiful in the Hawaiian Islands, and are quite numerous, at least as to variety, on the Asiatic shores. Efforts made to acclimatize the oysters of the Atlantic coast in California waters have been only partially successful.

The oyster no doubt furnished a large part of the food of man while in the primitive era of cave-dwellers, and we have evidence, not only in history but in our own day and generation, that it is sought for food both by savage and civilized man, as well as by the fishes of the sea; even the quadruped animals find it a toothsome morsel. You can prove this at your doors near Tampa Bay, where "coon" oysters grow plentifully, even upon trees and bushes. They derive their name, perhaps, from a fancied resemblance to the tongue of the raccoon, as well as from the habit these quadrupeds have of seeking oysters when the tide is out, cracking the shells and eating the oysters almost as the squirrel does nuts. I have often chased them from the oyster bars.

Plato, some 400 years before the Christian era, regarded the oyster as the typical know-nothing of creation, and he judicially consigned the soul of the ignorant man at death to the occupancy of the oyster. Oysters are unquestionably among the oldest of foods of mankind. Going back into history, we find that they are written of by the ancients as of prime importance in their accounts of feasts of the wealthier Romans, where they figured prominently in the lavish luxury of imperial Rome. Over 1900 years ago one Sergius Orata turned Lake Avernus, in Italy, into an oyster-bed. Sallust, before the Christian era, some 2,000 years ago, seems to have thought the oyster the only good thing that Britons had. Pliny, who died in the year 79 A. D., gives an account of the use of oysters, and mentions that Æsop's son was fond of them. Juvenal, A. D. 60, speaks of the British oyster, which was then in high repute among the luxuries of that day. The oyster has honorable mention in classic song and story and is a favorite theme for naturalists, but is not mentioned in the Bible. A physician, Dr. Baster, as quoted by Dr. Johnson, was of the opinion that the Roman predilection for oysters was a sanitary one, and he says:

> Living oysters are endowed with the property of medicinal virtues. They nourish wonderfully and solicit rest; for he who sups on oysters is wont on that night to sleep placidly. As to the valetudinarian afflicted with a weak stomach, oppressed with phlegm or bile, raw oysters are more healing than any drug or mixture that the apothecary can compound.

This mode of quieting the appetite for dinner appears to continue to the present day. A diet of raw oysters is an excellent remedy for dyspepsia.

The Pilgrims landing on the shores of what is now Massachusetts found oysters in great abundance and used by the Indians, and oysters were served at the first Thanksgiving dinner on this continent. The oyster industry of the world is chiefly in the United States and France. A few natural beds yet remain in Great Britain and France; the latter country has the best conducted oyster-culture, and seems with Holland to monopolize the trade of Europe, especially in oyster seed and the culture thereof.

In the census of 1890 the United States, in a comparative statement, is credited with an annual catch of 5,550,000,000 oysters, France 680,400,000, Great Britain 1,600,000,000, and Canada 22,000,000; the catches of the rest of the countries of the world are comparatively small, with Holland and Italy in respective order, the total for Europe being 2,331,200,000. The eastern coast of North America produces as much as all the rest of the world combined, and this very fact is full of importance to us in the consideration of the matter before us.

About 100 years ago the French and English oyster supply was supposed to be inexhaustible, yet it was not long before they were fighting for legislation, just as we are doing to-day. The first legislation respecting oysters seems to have been during the reign of James I, about 1606. The features of this legislation, cooperated in by both countries on account of the contiguity of their oyster-beds in the English Channel, and in effect to-day, is largely what we have learned by our own experience, not only in the northern waters but in Florida, viz: No dredging, except in private beds; a closed season, May 1 to September 1; oysters less than 2½ inches thrown back on the reefs; no ballast thrown on any oyster-bars. The customs officers are authorized to enforce these laws.

Such are the avarice and cupidity of man that through all these thousands of years he has not learned that it is the greatest folly to attempt to live on Nature's bank account without providing some return for the drafts made. All America, and Florida especially, with all the experience of the past to profit by, is destroying her natural wealth in every direction.

As before stated, oysters are found along the North American coast all the way down to the western end of the Gulf of Mexico. They are apparently much of the same nature, but some naturalists claim that the southern oyster is different from the northern; yet both varieties are found not only in Long Island Sound but in the Gulf of Mexico, and while growth changes their appearance it is owing to the nature of the surroundings—the bottom, the water, and the food. The principal oyster-grounds of the world are in the Chesapeake Bay. The abundance with which Nature blessed that region may not endure through the next half century without further protection by legislation, yet it is likely that there will be at all times public oyster-grounds in the United States, as in England and France, although any attempt to interfere with the so-called rights of fishermen on the oyster-banks has always met with strenuous opposition.

A hundred years ago oysters were plentiful from Maine to the Delaware Capes, and while some few are still found about the northern coast of New England, they are not sufficient to make the business profitable in that section. Along the Connecticut and Rhode Island coasts and down into Long Island Sound the oyster interests are managed in an energetic and systematic manner. New Haven is the pioneer in Euro-

pean shipments, and that section yet holds that trade, the bulk of their oysters being sold as barreled stock. The oysters there were threatened with the same extermination as their northern neighbors, but the dealers finally realized the condition and successfully propagated and transplanted oysters from Chesapeake Bay. Some of the wealthiest and most extensive oyster firms of the world are located in Connecticut. The first shipping ventures were failures, as the oysters would not keep their valves closed long enough. This was remedied, however, by placing them deep side down or "right" side up, and in some cases the oysters were wired. The industry has increased yearly, and will no doubt continue to increase in that section so long as other sections consent to sacrifice their own oyster farms for the benefit of their rivals. The true secret of their success, however, is that the people respect the rights of others and confide in and respect the courts.

When a reputation has been made for a certain class of oysters in the North, it never dies out. For example, take the "blue points" and famous "saddle rocks." The latter were discovered in the neighborhood of a submarine rock of that name, and the "trade-mark" became famous in the northern metropolis some thirty years ago. The beds were cleaned up in two seasons, yet New York has never lacked "saddle rocks" from that day to this. The term is now only a name for large oysters, as "blue point" is for any small oyster.

The oyster planters of Long Island Sound must continually wage war against that terrible enemy in those waters, the starfish. These pests, like the "borer," will not live in fresh or brackish water. They require a strong ocean brine as their natural home. They are the enemy of the oysters on the ocean front as the army-worm is to the crops on land. The "borer" or "drill," as well as the starfish, murders thousands of oysters in a season and causes a constant demand for fresh seed or plants from other localities. It is no infrequent occurrence for oystermen to dredge up as many as 75 bushels of these pests in a single day's work, and a steamer has hauled up several hundred bushels in a day.

Some years ago our Connecticut friends found that the use of bare bushes planted on the beds greatly increased the yield of oysters, as young spat clings to the branches and develops rapidly; but it was claimed that oysters caused typhoid fever, and that it was due to the presence of these bushes, so a law was enacted which prohibited this method of cultivation. The best evidence that this was a mistake is found in the fact that typhoid fever developed in this section after the bushes disappeared, and the blame was then given to the oyster per se rather than to the manner of cultivation. But an expert commission of medical scientists has recently investigated this matter and found that typhoid fever was not traceable to the use of oysters.

The oyster business of the Chesapeake Bay, according to the last census of the United States, represented the larger part of the entire value of the whole American fisheries—more than double the entire value of the cod fisheries of the Newfoundland banks. It employs many thousands of people and is the perennial source of an immense business. There is no question, however, that the catch of oysters of the Chesapeake Bay region has fallen off lately. Just as in Florida, the tide-water counties of Maryland and Virginia look upon oysters and fish as public property. Human nature is the same in the frozen north or the tropic seas. If the State properly managed the matter it would yield revenue enough to pay a large part of the expenses of the State government. Yet adjoining States should cooperate in this legislation.

The oyster catch of Maryland and contiguous waters has in the past decade shrunk to about half of what it once was, but the steadily increasing population of this country and the consequent increased use of oysters, together with the decreasing yield of Chesapeake oysters, have of late years resulted in creating a demand from other fields; so Virginia, North Carolina, Georgia, and especially Florida, Mississippi, and Louisiana, have come into prominence in this industry. There was a time in the history of the oyster trade of the Chesapeake when the catch was so considerable that the oyster-canning plants of Baltimore were really the salvation of prices to the oyster shippers and dredgers. Such is the case no longer, as Baltimore has now numerous competitors, not only in raw, but cove oysters, and not only in Maryland and Virginia, but in all the Southern States that border on the Atlantic and Gulf. I think that no State south of North Carolina has been more successful in this respect than Mississippi and Florida. The Mississippi oysters from Biloxi and those from Louisiana seem in a fair way to take possession of the western markets along the Mississippi River. Chicago has become especially interested. The sounds and bayous that border on the American coast all the way to the mouth of the Rio Grande are more or less productive of oysters, but many of them are of so delicate a nature, on account of the warmth of the water, that when steamed they seem to evaporate, and the shells in some cases are so soft and thin that they will not stand transportation. Where oysters grow naturally in localities which are favorable as regards salinity, lime, warmth of water, and abundance of food, the flavor and firmness are finer than when they have to be changed, and this is the spot on which to transplant and which should be cultivated.

There is nothing of interest, as I understand, to be said of the Pacific coast in respect to oysters other than that already spoken of; but some authorities say that excellent oysters are found on the coast of Bering Sea, so that at no far-distant day Alaska—besides her gold and salmon—may yet become the oyster region of that great Northwest.

Oysters are commonly believed to be unfit for food except in the months containing the letter R. This comes from the idea—and the fact also—that it is usual to find most oysters in spawn from May to September. As a matter of fact, oysters spawn at different times on different beds, according to the depth and temperature of the water. In deep water the temperature is less, hence the spawning begins later in summer and ends later in fall. On the other hand, the shoaler or warmer the water, the earlier the spawning takes place. Although wholesome oysters can almost always be found at some point from May to September, yet it is safest to be governed by this direction of the "R."

## NATURE AND GROWTH OF THE OYSTER.

This palatable and nutritious animal, while apparently very simple, has a complex anatomical structure, manifestly a beautiful adaptation to the creature's necessities. There is no certain method of telling the age of an oyster from its appearance, but it can be approximated quite closely by those accustomed to handling them. It is said that they have been found twenty years old. Dr. W. K. Brooks, of the Johns Hopkins University, of Baltimore, and the late Professor Ryder, of the United States Fish Commission, are recognized authorities in the United States whose researches as to the anatomy and physiology of the oyster are accepted and followed by those interested in the propagation or culture of this bivalve. Their observations and

conclusions are set forth in a recent article in the United States Fish Commission Report for 1897, by Dr. H. F. Moore, to which students of this subject should refer.

It has been estimated that a large female American oyster in perfect condition can furnish 60,000,000 eggs in one season, yet it is possible that only a dozen of these will reach adult age. The European oyster produces only about 2,000,000 eggs. Oysters are fond of the tranquil waters of gulfs formed by the mouths of rivers. They are sensitive to light, as is proven by their closing the valves when reached by the shadows of a boat.

ENEMIES.

The oyster has many enemies. The starfish and borer are not found in Florida, but the oysters of this State are exposed to storms that cover them with sand; to freshets that deposit mud upon and kill the young as well as the mature; to freezing, which destroys those exposed by the tide, yet if the tide covers frozen oysters before thawing they will not be killed; to droughts, which starve them. Mussels grow with such rapidity, wedging themselves closely between the shells, as to starve the oysters to death by preventing them from opening their mouths to take food. The adult oyster also feeds upon the spawn. The drumfish, the sheepshead, the crab, the oyster bird, are all destructive influences and tend to prevent the development of more than a minute percentage of the fertilized eggs. Even a heavy storm, as well as thunder, checks spawning and often destroys the spat.

OYSTERS IN FLORIDA.

The first landing of white men in this State found the Indians acquainted with the edible value of oysters, which had no doubt always furnished food for the aborigines, as evidence has been found showing the prehistoric use of oysters in this State. The principal oyster-beds on the Atlantic side of Florida are found at or near Fernandina, where oysters are plentiful; the Indian River region comes next, with the best condition at the southern end of the river. New Smyrna, at the mouth of Mosquito Inlet, is especially adapted to oysters, but very few are found in Lake Worth, and none of any consequence until the gulf at Hillsboro Bay is reached, where the natural conditions are excellent; then Sarasota Bay and Charlotte Harbor; then Cedar Keys and Crystal River, in which vicinity the physical features are preeminently favorable for oyster cultivation. Experiments in transplanting were tried near here some few years ago and with some success, but were abandoned on account of depredations. Some oysters are found near St. Marks and in Ochlocknee Bay; none in St. Joseph Bay; St. Andrews furnishes a fine oyster to a limited extent, but they will not bear shipment on account of their soft thin shells. Escambia Bay has some good oysters and here transplanting was also tried, but failed on account of depredations. Oyster-planting can not flourish in any community where the moral rights of the owner are not respected. Favorable oyster-grounds formerly existed in Perdido Bay, but a hurricane in 1896 virtually destroyed the oysters in this region. There are also isolated beds along the Atlantic and Gulf coasts. The more extensive beds have been of late years near Apalachicola, but they have been impaired by gales, freezes, and freshets. The extent, conditions, and peculiarities of the oysters of the west Florida coast I shall not comment on, but leave to Lieutenant Swift, who has carefully studied the region.

The influences threatening the permanency of the oyster supply of this section, as elsewhere in Florida, are not so much the consumption of full-grown oysters as the destruction of the young and the failure to protect the spat in the spawning season.

the land tenure, which are very uncertain and liable to be changed by any legislature. Without specifically outlining any law, I beg to suggest that from my extended practical experience and special personal observation within and without the State, as also my observation in legislation on this subject, a statute is required that will do the greatest good to the greatest number in protecting the natural beds or reefs.

The State should exercise exclusive jurisdiction and control over all fisheries. A positive and lasting definition should be made as to natural reefs and barren bottoms. In this it must be determined precisely by metes and bounds what areas can be used for cultivation. It takes an investment of money with energy and labor to engage in oyster-planting.

An oyster and fish inspector should be appointed in the coast counties without the influence of local politics, requiring a graded license tax for boats, as well as a tax on the catch to defray the expenses of inspection and the due enforcement of laws.

The use of dredges should not be permitted.

If a bar is exhausted it should be closed to all fishermen for a time.

No oysters under 2½ inches should be marketed. The practice of the older States is to permit not exceeding 5 per cent of small oysters or culls when marketed.

Oysters should be culled on their natural beds, small oysters or culls and shells being returned to the water.

Last, but not least—in fact, the most important of all—no oysters should be permitted to be used for any purpose whatever during the closed season except for transplanting. Although the spawning season varies, depending on the depth of the water and temperature of the air as well as conditions of food, a fair and reasonable limit is from April 15 to October 15. I will tell the oystermen it is folly for them to attempt to cure these ills by law, for they know by experience it can not be done without their aid. I do not see any other way to bring it about except by public sentiment. The State can not do anything on this line without the cooperation of the oystermen, for it has so far in other States proved a failure. At no time has this subject received so much attention as now. It has for many years been a subject for legislation, yet no system has been established equally satisfactory to oystermen and the public at large.

An opinion prevails that the State should sell the natural reefs and let the owners thereof look to the protection or improvement. This would be against the interests of those dependent on the oyster industry for support, and it would not promote or encourage peace and good order and should not be considered.

APALACHICOLA, FLORIDA.

# THE LOUISIANA OYSTER INDUSTRY.

By F. C. ZACHARIE.

The great resources of Louisiana, in its large production of sugar cane, cotton, rice, lumber, and fruits, have hitherto kept in comparative obscurity what are generally deemed the minor, and wrongly considered the less remunerative, fields for the employment of capital and intelligent labor. Many of these are so regarded simply because the best locations for their development have been until recently remote from the centers of trade and great waterways and, in many instances, difficult of access by quick transportation. This possibly accounts for the general ignorance of the great opportunities which these industries offer for highly remunerative investment.

Prominent, if not the principal, among these neglected interests are the vast fishery interests of the State which, under energetic labor and scientific cultivation, would in a few years equal, if they did not surpass, in the way of pecuniary profit, the aggregate value of the entire agricultural product of the State. The extent of the oyster territory is so vast, the supply so abundant and cheap, and so little labor and capital are required for development, that, once known, capital and labor will inevitably seek employment in what must eventually become a leading industry, far surpassing that of any other State in the Union in this respect.

On the eastern boundary, starting from the Rigolets, the small gut or strait connecting Lakes Borgne and Pontchartrain, and following the shore line southward and westward around the mouths of the Mississippi River to the Texas line, there is a coast of about 600 miles in length, if measured on straight lines from point to point. Making an allowance for the curvatures of the coast, the shores of salt-water bays, bayous, inlets, lakes, and islands, which fret this part of the State like network, the littoral line will not fall short of 1,500 or 2,000 miles. Taking into consideration the shelving, shallow beach adjacent to it, experts well acquainted with its geographical features estimate that the area suitable to planting and growing oysters is equal to the amount of acreage available in all of the other States of the Union combined. By far the larger part of this extensive coast was dotted by extensive natural oyster-reefs, originally—that is, in a state of nature—only distant from each other a few miles. Those most accessible to speedy transportation to market have been in some cases almost entirely denuded, and others seriously impoverished by the constant fishing in and out of season. In still other instances the fresh water from river crevasses has occasionally, but only temporarily, injured the productive capacity of the beds. These injuries are, however, but occasional and temporary, as we have just said. The fecund, recuperative power of nature, in no way more strikingly illustrated than in the immense reproductive capacity of the oyster, soon replenishes the stock, whenever the depredations of fishermen or the overflow of fresh water cease, and the beds are allowed to rest for a time.

Besides these natural beds, the coast abounds in suitable places in which the mollusk can be transplanted from the seed bed and under proper care developed into an oyster which, for the delicacy of its flavor, can not be excelled the world over. East of the Mississippi River these natural beds are still numerous, and transplanting is carried on to but a limited extent. Not only do these beds supply the wants of the people of the lower coast, but small quantities are shipped to the New Orleans market, and poachers, or "pirates," so called, from Mississippi carry away annually hundreds of schooner loads of the shellfish. A fleet of lumber schooners, said to be capable of carrying from 1,000 to 2,000 barrels and supplied with shallops and dredges, effectually comb the beds of St. Bernard Parish. In addition to those thus gathered large numbers are crushed and broken by the dredges, while others are buried in the mud, which covers and smothers them. These oysters thus removed are not culled on the banks, but are carried and sold in the rough, just as they come from the water, to the canneries on the Mississippi Sound for prices varying from 30 to 60 cents per market barrel.

The flavor of these bivalves here taken, although of excellent quality compared with those of the Atlantic States, is by no means equal to those taken from the choice planting-grounds across the Mississippi, going west from the great river. Bayou Cook, Grand Bayou, Bayou Lachuto, Timbalier Bay, Last Island, Barataria Bay, Wine Island Lake, Vermilion Bay, and the Calcasieu grounds furnish the best, those of Bayou Cook having the highest reputation in the markets of Louisiana and the neighboring States and bringing a correspondingly higher price.

The manner of cultivation, if it can be dignified by that name, and the methods of fishing and forwarding to market are of the most primitive character, and the capabilities of production have as yet been hardly demonstrated. The fishermen are mostly uneducated Austrians from the Slavonic provinces, commonly known as "Tackoes." Small colonies of them "squat" on any available shore, generally along some stream, bay, or lake emptying into the Gulf, regardless of the ownership of the land, erect their huts, and with the capital of a pair of oyster-tongs, a skiff or two, and a small stock of rough provisions, usually advanced by the dealers in the city, embark in the trade of oyster fishing. Few of them own luggers or engage in the business of forwarding their oysters to market. From time to time they recruit their helpers from the freshly arrived of their countrymen, who, knowing neither the language nor the country, go to "learn the trade" at nominal wages as a sort of apprenticeship, receiving board and lodging, such as it is, as part compensation for their labor. The master fisherman or "captain," as he is termed, thus equipped and assisted, starts out in the planting season and transports from the natural bed skiff-loads of the shellfish, which he deposits in the brackish bayou or lake which he has selected near his cabin, marks his beds of "plants" with stakes to designate his ownership, and keeps "watch and ward" over his possessions until his crop is ready to ship to market. Others do not plant at all, but only fish the natural oysters from the bed and sell to "luggermen."

The planted oysters transferred from the natural beds, where the sea water is very salt, soon feel the beneficial effect of their changed condition. The fresh-water streams, draining the rich alluvial highlands, bring down in profusion infusoria and other low forms of vegetable and animal life on which the young oysters thrive. They commence immediately to fatten and alter the shape of their shells gradually from the lank and slim form somewhat similar to an irregular isosceles triangle, broad at the

hinge and diminishing in breadth, until they narrow down to what is commonly, but erroneously, called the mouth, forming somewhat of a wedgelike contour, to a more rotund or parabolic shape as they grow larger. The rapidity of growth of the Louisiana product is marvelous. In the North Atlantic States it takes nearly three years, as we understand, for the fish to mature from the seed, so as to be marketable. In the Louisiana waters it takes hardly more than one-third of that length of time.

When sufficiently matured, say to an average length between 4 and 6 inches, the time of fattening and growth depending to a great extent on the size when transplanted and the richness and abundance of the food in the locality, the crop is ready for marketing. During the fattening process, however, the plants are subject to a variety of diseases, although not so numerous or so fatal as those in the colder waters of the North Atlantic, nor are they exempt from other destructive agencies. Schools of drumfish and sheepshead prey upon the beds, crushing the shells easily and devouring at times in a single night hundreds of barrels of oysters. Crabs also devour the young oyster, while a number of crustaceous borers and starfish find their way through the shells and kill the young brood. To guard against these depredations, although ineffectually in most cases, pens formed of stakes driven in the bottom of the stream are erected around the plants.

The planting we have alluded to consists in strewing the natural young oysters in thin layers over a hard bottom, which has previously been selected and located, or at times artificially created by deposits of old shells. In gathering or "tonging" the oysters from the natural beds, 20 barrels per day is considered a good day's work per hand. This, however, is rarely reached, owing to the unreliability and inferiority of the labor. The "Tackoes" are not by disposition an industrious people, and, like all the people dwelling near the shores of the Mediterranean and Adriatic, they are inclined to the *dolce far niente*, and are peculiarly sensitive, from their former habitats, to the effects of the cold northers of the Gulf. Moreover, they are timid sailors and dread the sudden storms of our southern waters. They are careless and heedless of waste, and it is a common practice, although contrary to law, to "cull" the natural oysters, and for that matter the plants as well, on shore or while under sail from the beds. The fatal effects of this practice will be readily perceived when we state that it consists of scraping and knocking off the myriads of embryos of young oysters which adhere to the older ones, and which should be dropped back into the water upon the beds, to be thus preserved and matured, but instead are dropped on land or in the water away from the beds and there left to die. This is but one example of the ordinary run of the "Tacko" oyster fishermen. Nor is this confined to the people of this nationality alone. It may be said to be general among nearly all the fishermen.

The report of the United States Fish Commission of 1880 says:

> The shipment of oysters from New Orleans has hitherto been very small, and principally of fresh oysters. * * * Work is irregular because of the difficulty of getting oysters in sufficient quantity and when needed, owing mainly to the indisposition of the oystermen to work in bad weather.

There are no statistics at hand by which the total of the gathered crops can even be approximately estimated. Prices vary considerably, according to the weather and the season. Small, natural, unplanted oysters, commonly called "coons," suitable for planting, can ordinarily be purchased at from 25 to 60 cents per barrel, delivered free on board at the beds. Fully matured plants vary in price at the plant beds from $1

to $2 per barrel, according to the reputation of the place from which they come. These "barrels," however, are what are technically called "bank measure"; that is, 2 "bank measure" barrels make about 3 barrels when sold in market. When the planter finds that this crop is sufficiently matured and fat, ready for market, say six or eight months after being transplanted, he bargains and sells to the "luggerman" on the ground. A few planters own or have their luggers and ship for their own account. The "luggermen" transport their purchase to market, generally to New Orleans. The trip to the city usually takes from two to three days, a part of the journey consisting in threading narrow, shallow, and tortuous bayous. Adverse head winds sometimes delay the passage so long that the cargoes are unmarketable on reaching their destination. Sometimes, where practicable, "cordelling," or hauling the luggers by horse or man power, is resorted to, and at times steam towage, when accessible, is employed, all of which, of course, is an element of further expense.

Arrived at New Orleans, the luggerman disposes of his load to the dealers, who supply the local trade and ship to neighboring cities. Prices range according to the supply. Favorable winds may serve to bring in on the same day a large fleet of oyster-laden craft to "Lugger Bay," as their landing opposite the French Market is called. The market consequently becomes overstocked and glutted. If to this is added simultaneously a sudden change of weather from cold to warm, a not unusual thing in this climate, the luggerman is forced to sell at a very heavy loss on purchase price or unload his cargo into the river. Besides these adverse contingencies, there are the ordinary accidents of navigation, such as grounding and remaining so for several days in the low tides in the shallow lakes and bayous, and storms of several days' duration, when the timid luggerman, who shortens sail ordinarily on the slightest rise of wind, now anchors or "ties up," and awaits its cessation. Then, too, the cargo is in considerable risk of being killed while in transit. A violent collision with the bank or another vessel, a violent hammering on the deck, and even heavy peals of thunder, have been known to "deaden" the whole cargo, and if the weather be warm and the market not close at hand there ensues a complete loss.

With all these disadvantages, however, which could easily be obviated by prudent and proper precautions, and in spite of the heedless, thriftless, and primitive manner in which the trade is carried on, these Austrians amass, in nearly every instance, considerable profits, make what are to them handsome sums and respectable fortunes, and usually retire to their native land, there to live, with their few wants and the Continental cheapness of living, the balance of their lives in comparative affluence for people of their class. These fortunes are ordinarily realized in a few years, seldom more than ten or twelve. On retiring, the fisherman disposes of his hut and outfit, oyster-beds, tools, boats, etc., with the good will of an established business, to some relative or friend whom he has imported to the country for the purpose, or perhaps to some of his helpers who have saved a little money. In some instances good round sums are realized by these sales. In others, the retiring vendor retains a share in the business and draws a portion of the profits, occasionally paying flying visits to this country to look after his interests.

Most of these men can neither write nor read English or any other language, nor do they speak or understand any tongue save Slavonic, and when dealing with those other than of their own nationality require the services of an interpreter. These small fortunes, which they amass in so short a time, generally consist of sums varying from $5,000 to $15,000 or more. Considering the smallness of their operations, the light-

ness of the labor, the exceedingly limited character of their business in every respect, the utter want of scientific or practical knowledge of oyster-culture possessed by them, the acquisition of such sums in so short a time is marvelous. And yet when we consider their manner of life and their immense profits, hereafter shown, it is easily comprehended. They "squat" on any lands, public or private, for which they pay no rent. Hitherto they have paid no rent or taxes of any kind. They pay nothing for their oysters if they tong them themselves. They subsist on fish, which are plentiful and easily caught at all seasons, supplemented with poultry, which they raise, and game of all kinds, which abounds at proper seasons. In some cases they reclaim a portion of the marsh land in the neighborhood of their cabins by filling it in and cultivating vegetables thereon. During the "close" season, when only a small quantity of oysters are illegally or surreptitiously marketed, they engage in other profitable pursuits. Their expenses are almost nil, outside of a small account for store provisions and rough clothing, and their proceeds are almost clear profit.

In addition to the sale and shipment of fresh oysters, large profits have been realized by the canneries, which have been established from time to time; but as the oyster supply in their neighborhood has been diminished by indiscriminate and unseasonable fishing, and as the prices have increased, some of these establishments have removed to more favorable and lower-priced localities where their materials could be purchased almost on their own terms. The canned oysters shipped from Louisiana until recently have always been of the poorest and cheapest quality, subjected to the "bloating" process by continued "floating" in fresh water, and then canned by some imperfect process which imparts to them an unpleasant and "woody" taste. All these practices have combined to give Louisiana oysters an unfavorable reputation in markets outside of the State, though when properly prepared connoisseurs have pronounced them equal, if not superior, to the best of Chesapeake Bay or those of any of the other eastern fisheries.

If we turn from this primitive, loose, and careless method in which the oyster industry of Louisiana is at present carried on, and compare it with the skill, industry, and science with which the industry is conducted in the Eastern States and in Europe, and then consider the vast area that the Louisiana oyster-grounds present, the warm waters of the Gulf, the richness of the food, and the numerous other superior advantages which their situs affords, there dawns before us a field for investment, with such rich returns therefrom, as is scarcely presented anywhere else in the wide world in this or any other employment of men and money.

Let us for a moment illustrate the enormous profit accruing to these primitive planters and luggermen. A bank barrel of coon oysters will, when transplanted for six or eight months, increase to 1½ barrels by reason of growth. The coon oysters can be obtained free from the natural beds at no cost except the price of labor. If purchased, they cost 30 cents per barrel. This 1½ barrels is sold to the luggermen at from $1 to $2 per barrel at the plant beds. When the luggerman sells at the city market he obtains from $3 to $4 per market barrel, 2 bank barrels making 3 market barrels. Thus the bank barrel of fish which the luggerman has bought at $2 brings him 1½ barrels (market), or from $4.50 to $6 per bank barrel. If the planter himself ships he would obtain $6.60 for what he has paid 30 cents, or obtained for nothing if he fished for them. The same would be relatively true, only with a smaller amount of profit. where natural oysters are transplanted and so kept a few weeks simply to improve their condition by fattening before shipping.

As the trade is at present carried on the planter gets the benefit of the first difference in growth, and the luggerman the advantage of the difference between the bank and the market measure. Thus a person who both plants and markets his oysters, as we have said, would pay 30 cents a barrel bank measure, and from that barrel he would gather 1½ bank barrels of mature, marketable oysters, which, selling at, say, $3, he would get $6.60 for what he originally paid 60 cents. In other words, 1 bank barrel of coon oysters worth 30 cents expands into 1½ bank barrels of plants in six or eight months, which is 2¼ market barrels, worth from $3 to $4 each. At $3 per barrel the 30-cent purchase becomes worth $6; at $4 per barrel, $9. Of course, these prices are predicated on the lowest buying and selling rates, and on the basis of large purchases and sales in an ordinarily favorable market. These profits would be immensely increased if the spawn were scientifically protected, and the immature oysters were preserved from disease and numerous enemies by proper precautions now universally in vogue in the older countries and fully described in The Oyster by Professor Brooks; Oemler's Life History, Protection, and Propagation of the American Oyster; the reports of the United States Fish Commission; the reports of the oyster commissioners of many States, and other American and European literature on the same subject.

That the field for investment is an inviting one, and is gradually becoming recognized as such by investors both within and without the State (and must become still more so as the subject is investigated and studied), is shown by the formation of several incorporated companies now engaged in the development of the industry. Outside of many small individual efforts in that direction, several associations have been formed, prominent among which are the Gulf and Bayou Cook Oyster Company, Limited, which owns the major portion of the lands in Bayou Cook and the valuable planting-grounds thereunto appertaining, and also the Louisiana Fish and Oyster Company, the latter of which is now in active operation, and the former will soon be, having just successfully terminated a long litigation with some of the Tacko "squatter" fishermen.

The legislature of the State has just recently passed prudent acts for the protection of the fisheries, reserving the natural beds not heretofore granted for public use during the "open" season, providing for a somewhat proper police, as well as the leasing and selling of the State lands suitable for planting at moderate rates, and exacting a minimum tax to execute the law. The right of fishing for oysters is reserved to the citizens of the State alone. This law—which is imperfect in not closing for a longer period in each year the natural oyster-beds, which have well-nigh become exhausted, so as to allow them to recuperate and to be restored to their pristine fruitfulness—will probably be amended and perfected by future assemblies as the legislative mind becomes more educated on the subject, as it has been in the older States that have undergone the same experience in this respect.

The Louisiana legislature at its last session passed a resolution (No. 136 of session acts of 1896) that—

> The United States Fish Commission be requested to investigate the oyster-spawning season and report to this general assembly before its next session the exact season of the oyster spawning in this State, and all other facts respecting the same, and whether or not the present existing laws are not injurious to the oyster industry of this State.

Of course such improvement will be strenuously opposed by the uneducated fishermen and the avaricious luggerman and dealer, who look no farther than the present

rofits of the day and care not for the future, although if they did but know it they re more vitally and immediately interested than all others in the prevention of the uin of the fisheries. In pursuance of this resolution the United States Fish Commission steamer *Fish Hawk* will, we are informed, immediately on the adjournment of this Congress proceed to make the investigation requested, and will report thereon to the ext general assembly of the State, which meets in May of this year. Without tresassing on or unduly anticipating the recommendations which will then be made, we enture to suggest consideration of the following points:

(1) The establishment by the State of a fishery commission to protect and regulate nore effectively the oyster fisheries as well as the fin fish, both salt and fresh.

(2) The establishment of a station by the United States Fish Commission on the Louisiana Gulf coast convenient to New Orleans as a distributing-point for the Gulf nd interior States.

(3) The closure for several years of those natural reefs and beds which are now n the point of exhaustion.

(4) A prolongation of the ordinary close season from April 1 to October 1, as it as been shown that this interval of time is used for spawning, which is not confined o May, June, July, and August, as heretofore thought. During the six months of close eason suggested the sale of oysters of any kind should be prohibited, whether from rivate beds or public reefs. Dealers, common carriers, and others should be punished or transporting or dealing in them during the close season, the same as under our game laws. The present law allows the sale from private beds, although ordinances f the city of New Orleans prohibit the sale of oysters of any description from May 1 to September 1 of every year. The allowance of sales from private beds during the closed eason opens the door wide to indiscriminate selling and renders the law inoperative nd incapable of execution.

(5) Persons found with unculled oysters in their possession in any other place han on the banks should be severely punished.

(6) Every incentive and inducement should be held out by legislation to encourge the culture of the oyster and the use of natural reefs should be confined, as far s possible, to supplying seed, to be planted and improved by cultivation. To that end iberal sales and leases for terms of years should be granted on the public lands and aters suitable for oyster culture. Riparian proprietors should be given and granted he right to plant and cultivate oysters to a certain distance on their water front and ther means should be resorted to, in order to offer inducements and accord liberal reatment to capital to develop this enormously valuable industry, which has as yet ardly been touched.

Perhaps obstructions to improvement are always to be expected from the ignorant. n New Jersey, where such extended closure of seed beds was similarly opposed (as was in France and other countries), the commissioners tell us "all the opposition fered at the outset of this proposed system of protection has now disappeared, and ose who were loudest in their protestations have acknowledged their unfounded ejudice and error. All of the seeding-grounds of Delaware Bay enjoy a rest of 9½ onths each year. As a result the beds have increased in area and new beds are ntinually forming, and the supply is increasing to a wonderful extent." If the gislature of Louisiana will follow the wise example of those older communities and

also prevent the use of natural beds except for seeding purposes, and thus compel and induce the proper cultivation of the oyster, a mine of untold wealth will be opened both for her own exchequer and the people.

The difficulties, dangers, and delays of transportation are being rapidly overcome by railways and canals—some already built and others projected—penetrating many of the best oyster regions; and if capital be properly encouraged and protected in its investment, as it assuredly will be, the day is not far distant when the product will be immeasurably increased, the price for home consumption greatly reduced, and an export trade established which will supply the whole of the Western territory of the United States, from the Mississippi to the Pacific coast, at reduced prices. Not only to the capitalist is the field open, but to the skilled oyster-culturists of Chesapeake and Delaware bays, Long Island Sound, and the Connecticut shores the State offers cheap oyster-lands for sale or rent, and a free supply of seed. To all such, with a minimum of capital but with skilled industry and energy, she opens her arms to welcome them to a home on the verge of her "summer sea," beneath skies which hardly know what winter is, and to cheer them on to fortune and her own industrial development. This is no fair-seeming but false promise, but one tendered in all sincerity and based on facts which the writer has been careful to understate rather than to overestimate.

NEW ORLEANS, LOUISIANA.

# THE OYSTER-BARS OF THE WEST COAST OF FLORIDA: THEIR DEPLETION AND RESTORATION.

By H. A. SMELTZ, A. M.

One of the greatest benefits the State of Florida shall receive from the assembling of this Fishery Congress is the good influence on public opinion, and from the closing session of this assembly our people will not only know more about oysters and fishes and sponges, but they will realize that all these things are being exhausted, so far as the natural supply goes, and also realize that something must be done, and at once, in order to preserve these bounteous natural gifts so lavishly poured out by nature's hand. The fact is, the natural oyster-bars are a magnificent inheritance that has cost us nothing, and we are not only using but abusing nature's providence by the most extravagant wastefulness and improvidence, and it is only by the education of the masses along these lines that we may hope for success in the restoration of our depleted oyster-bars and sponge fisheries.

In 1876 I came to the west coast of Florida from one of the largest oyster-growing sections in the world, Chesapeake Bay. I landed at Cedar Keys and at once became interested in the oyster-beds of Florida. After spending three weeks at Cedar Keys, I cruised southward, examining the most prominent oyster-beds, such as Crystal River Bay, the bars of the Cootie region, Clearwater Harbor, Point Pinellas, Hillsboro Bay, Old Tampa Bay, and on to a hamlet I found at the mouth of the Hillsboro River known as Tampa; thence I continued southward to the Alafia River, Big and Little Manatee, Sarasota, Boca Grande oyster-bars and 100 miles farther south, and on every hand I found the same condition—oysters, oysters everywhere. How little did I then think that in less than twenty-five years every one of these bars would be partially or totally depleted. On every hand I found these immense reefs and beds of oysters in such seemingly inexhaustible supplies that it frequently occurred to me that the great God of nature must have gone ahead of me and, with hands wide open, scattered right and left and out into the depths so far that I failed to find their limits. On the shores, as we landed from time to time, I found for about 150 miles, at short intervals, great mounds of oyster shells, often 25 feet high and 200 feet long, monuments of a magnificent oyster supply antedating all records and traditions, feeding races so far back that ethnology shakes her head and declares, "I never knew them."

But I hear someone ask, "If this west coast of Florida be so thoroughly adapted to the growth of the oyster, how is it that these wonderful bars should all be either partially or totally depleted?" Let us ask a second question: How is it that every oyster-growing section in the United States has had to meet and settle, in one way or another, this identical question of depleted oyster-bars? The answer in each and every case is: As long as any of the oyster-growing States were in the hands of a few Indians the demand never approximated the natural supply, and even during the early occupation of the country by white men, with its sparsely settled communities,

the demands were insignificant, and the oyster-bars increased and multiplied; but when the tide of immigration set in, and the sparsely settled communities became thriving villages, and mere hamlets became splendid cities, and in the place of the Indian's canoe and the early settler's bateau, came the sloops, schooners, steamers, railroads, and even the ocean steamers, demanding these oysters to distribute them to the east, west, north, and south, to say nothing of the increased home demand—when we consider all these constantly increasing demands, we see very readily that the answer to the question is simply that the demand is an hundredfold in excess of the natural supply, and the artificial supply amounts to nothing, and never will amount to anything, in Florida, as it never has amounted to anything in any other State, until by proper legislation oyster-raising is put on a business basis, the State giving every citizen who wishes to engage in the oyster business the same opportunities, the same rights, and the same protection she gives her citizens to conduct any other legitimate business.

As matters stand to-day in Florida, the oyster interests (I mean their protection and propagation) are everybody's interest, and on the west coast of Florida there are thousands of acres of land covered with water that are more valuable for food production than the best hummock lands, and yet neither the State nor its citizens get one farthing's benefit from them, whereas, by proper legislation, these oyster lands now lying idle could be sold or leased and put under the head of taxable property, and thus immensely increase the revenues of the State. Then, and not till then, will public opinion respect the property a man has in oyster-beds.

On this west coast of Florida we have all of the natural conditions—climatic, geographic, and hydrographic—and the extent of territory to establish an immense oyster industry, which would pay into the treasury of the State such revenues as would appreciably reduce all other taxes, and in this way I believe public opinion can most readily and most speedily be educated on the oyster question. Show a man (and the same is true of a State) that you can and will make money for him, and immediately you enlist his interest and his sympathy, when all your moralizing and sentimentality fall flat as a flounder.

But let us come to the practical and tangible part of the subject. Here I have hundreds of specimens of oysters brought from these partially depleted beds of the west coast, by which I wish not only to show the wonderful processes of nature in adapting itself to the various circumstances and often peculiar conditions under which the eggs attach themselves to any suitable object they may find in their wanderings, but also to demonstrate that there are still on many of these beds enough oysters left to furnish seed for their restoration by proper protection and timely aid, either by the State or its citizens individually.

In order to understand the subject before us more thoroughly, let us look at the oyster himself. Here we have an animal living in a limestone house which he builds for himself. He begins this house-building when he is four days old, and he continues to build and, as necessity requires, to repair this house as long as he lives. In the ages past the oyster was a swimming animal, as he now is for the short period of from five to ten days. At this period his two shells are equal; but after the period of attachment, which is by the left shell, the lower shell becomes cup-shaped and the right or upper shell becomes the lid.

The oyster makes his shell out of the gummy secretion of his mantle, which catches and fixes the lime of the sea water by some special process not yet thoroughly understood, thus creating a substance out of which he not only builds his shell, but repairs

very neatly all damage done any part of his shell, even to the making of a new hinge; or, should any foreign substance enter his shell which he can not expel, he covers it with this substance, and so rapidly does he work that he will put on the first coat or film in about 24 hours.

Lime for shell making is one of the prime necessities for the rapid development of the oyster, and all waters deficient in lime are by just so much unfit for the perfect development of the oyster. Oysters in waters deficient in lime have shells so thin (in both young and mature oysters) that they fall an easy prey to their enemies, and for the same reason are ill-suited for shipping to any distant market. Here, again, the west coast of Florida, with its coral sea foundation and its wonderful phosphate deposits along the shores, sending additional lime to the oyster-beds by every inflow of fresh water, presents very great advantages for the most rapid and perfect development of the oyster. This inflow of fresh water from the many springs scattered along this coast is of peculiar advantage to the oyster, because it reduces the specific gravity of the sea water to a point generally admitted to be most suitable for the rapid development of the oyster.

As to its anatomy: The oyster has a heart and blood circulation, as we find in other animals. He has a pair of lips, and a mouth situated in the back or hinged part of the shell (and not, as popularly supposed, in the front or open end of the shell). He has a full set of digestive organs—stomach, liver, intestinal canal, etc. His food consists of about 90 per cent of vegetable matter, about 5 per cent of mineral matter, and 5 per cent of a mixture of the reproductive organs of seaweed, etc. This vegetable food is chiefly diatoms (a low form of vegetable matter having the peculiar quality of great activity in the water). These diatoms are much more active during a bright, sunny day than on cloudy or foggy days, and this is another of the many reasons why the oyster in Florida (the land of sunshine) grows more rapidly than in other sections subject to cloudy and foggy weather, to say nothing of snow and ice and a general temperature of the water frequently below the point of advantageous feeding.

The natural food for the oyster, found in all sea water, can be supplemented by many land products. The two most desirable in Florida are the pollen of our pine trees and the bloom of our palmetto. By using the bloom of both saw and cabbage palmettoes this food can be furnished them for about five months of the year.

The oyster has not only sensory organs of smell, but eyes also to see. These eyes are, however, not highly developed, self-focusing eyes, as we find in animals of higher order, but rather a rudimentary eye or eyes scattered all over the body of the oyster, and so constituted that they serve the oyster in or out of the water as admirably as do the eyes of animals of a higher organization. The oyster has also nerves and brains, not highly developed, but sufficiently so for all his needs and purposes. The reproductive organs of an oyster are simply wonderful as to their capacity for egg-production.

Unlike the European oyster (*Ostrea edulis*), which is hermaphrodite, our American oyster (*Ostrea virginica*) is unisexual. By this I mean that every oyster lays each season either (and only) male eggs or female eggs; but I believe that it is an established fact that the same oyster that lays male eggs one season may lay female eggs the next season, or vice versa. The female, according to size, age, and vigor, will lay from 1,000,000 to 40,000,000 eggs annually. This calculation is based on the size of the egg as compared with the size of the ovarium at the time of laying. Both male and female eggs at the spawning season are swept out of the ovarium into the water, where the female egg becomes fertile by contact with male eggs. It is highly probable that not

more than 10 per cent of this vast number of eggs ever become fertile. The eggs not fertilized are either dissolved by the action of the sea water or are eaten by fish or other sea creatures. As soon as the oyster egg is fertilized changes take place very rapidly, and in less than 24 hours it begins to swim and is drifted about by tides, currents, or winds, but is always ready with its hair-like tentacles (cilia) to catch hold of any clean object with which it may come in contact and remain there for life.

This now brings us to the answer of the second part of our subject, "How can we restore the oyster-beds on the west coast of Florida?"

(1) By utilizing the eggs from the oysters left on these bars. On all these bars there are still enough oysters left for egg production, and by scattering over these bars from year to year, and just before the laying season, clean oyster shells (or, what is better, the small shells found in great abundance on this coast) to catch this spat, our bars will, if left undisturbed for a few years, be so restored that a reasonable amount can be gathered annually, and if not unreasonably drawn upon they will soon recover themselves.

(2) As, however, we have all along this coast and in the neighborhood of these depleted bars thousands of acres of raccoon oysters,[1] that are in every way adapted for seed, to plant on these bars, we can restore them in a comparatively short time by combining the two methods. The latter method is the one used in restoring the depleted bars of our Northern States. It is a simple matter of history that when our Northern oystermen found their bars depleted they sent vessels to the Chesapeake Bay and as far as the James River and bought small or seed oysters and scattered them over their bars, and from year to year not only take up and sell those of marketable size, but continue to import and scatter about a regular amount of seed oysters annually. Now, then, if it pay the Northern oystermen—and if it did not pay them they certainly would not continue to do so from year to year—to buy oyster seed and transport it several hundred miles, will it not pay the oystermen on the west coast of Florida to simply pick up, free of cost, and transport only a few miles this seed from the raccoon bars?

Inasmuch, then, as this coast by nature is so admirably adapted for oyster-growing, and as the natural bars still contain enough oysters for spat production, and as the oysters and many other kinds of shells are here in greatest abundance to be used as a cultch, and as there are thousands of bushels of good seed oysters in the immediate neighborhood of the depleted bars, I see no reason why, with proper State legislation and an enlightened public sentiment, these oyster-bars on the west coast of Florida could not be restored to their original splendid condition and in a few years be the means of considerable revenue to the State.

TARPON SPRINGS, FLORIDA.

[1] It is an established fact that we have but one species of oyster on the Atlantic coast (*Ostrea virginica*) and that the racoooon oyster is identical with the regular commercial oyster.

# NOTES ON THE FISHING INDUSTRY OF EASTERN FLORIDA.

By JOHN Y. DETWILER.

## EXPERIMENTAL OYSTER-CULTURE.

It is a well-known principle that flourishing animal life depends on special factors, the most important of which are the facility for obtaining food, the proper temperature of the medium in which the animal lives, and the indefinite continuance of the favorable conditions. Nature in her attempts to bring about the necessary conditions is pre-eminently successful, and only when man interferes or other disturbing elements exist do her efforts prove abortive.

The peninsula of Florida, with its coastwise resources, from the evidences remaining to us at this time, has in the past been teeming with food products that sustain human as well as animal existence. Modern investigation has proved that it is no less prolific under the existing conditions. Modern civilization, through the medium of scientific researches, aided by improved means of communication and transportation, has demonstrated that, by a judicious and thorough examination into the causes that bring about a certain result, nature's food supply can be greatly increased as well as preserved for the use of the present and future generations. Recognizing this fact, his excellency, Governor Bloxham, of the State of Florida, issued a call recommending that the sections of the State interested in this important subject be represented at a national congress of the fishing industries, to convene in Tampa on the 19th of January of the present year, to promote and advance this important industry.

As a delegate to this body, engaged in so laudable an undertaking, I feel highly honored in representing the locality embracing the Halifax and North Indian rivers of the east coast of Volusia County, Fla., a section of country once occupied by a race of people who subsisted mainly on the food products of the water, as is clearly demonstrated by the existence of shell-mounds located at many points on the peninsula and on the mainland, showing the great importance of the salt-water lagoons, bays, and estuaries, as well as the ocean, to keep up their existence.

It is useful to refer to the past merely as an indication of what has been accomplished by those who preceded us; our purpose is with the present, and how we can best advance the interests of mankind, increase our sea products, and preserve our present advantages. With this introduction permit me to advance a few thoughts on this subject in relation to the propagation and culture of the oyster, an industry of vast importance to all sections of the United States, for but few places exist in the civilized world where oysters, in some form, can not be procured.

Oyster culture on the southern seaboard, compared with the sections embraced in New York, New Jersey, Maryland, and Virginia, has not been as productive as could be desired by those interested in that pursuit, and for this reason, among others, we are assembled. That the proper conditions exist in localities no one doubts, but the successful propagation of the oyster under all circumstances, either natural or artificial, is to be considered and discussed, and some definite conclusion arrived at,

if possible. The environments and advantages possessed by individuals have much to do with their powers of observation, and I speak to you after a residence of fifteen years near New Smyrna Inlet, undergoing the trials that attend those who, with unbounded hopes and limited resources, emigrate to a new country, leaving behind all with which they were formerly associated, and relying on the natural food resources to a great extent for sustenance. These conditions bring mankind in close relations with nature, and through the necessities of the case nature's mysteries are unveiled.

The utilization of the salt marshes of the coastwise country for the propagation of the oyster is, in my opinion, the solution of this most important problem—not to ignore the planting of oysters in the creeks, bays, and open waters of the State, but to introduce an intensive system, as it were, that will ultimately insure success. There can be no success without effort, and to the brains and brawn of our land are we indebted for all we possess. The same effort expended in labor or capital in reclaiming a portion of our salt marshes for the planting of the oyster I sincerely believe will result in greater financial returns than in any investment that could be made in either orange, vegetable, or tobacco culture, all conditions being the same. I may be assailed as an extremist, but it certainly will cost no more to prepare the ground in one case than in the other. The cost of fertilizer, the packages necessary for transportation, destruction by frost, and the necessity of securing a market at once or meeting an entire loss—these considerations, with many others, are ever present with the agriculturist. The independence of the oyster-culturist arises from knowing that his product will keep until it can be disposed of advantageously, with no loss by frost or decay; and instead of seeking a purchaser, the purchaser seeks the product and pays a satisfactory price, and the producer only has to bag or deliver the goods. The conditions that now govern the transportation of Florida products are in favor of the oyster, for water communication renders competition possible and the industry profitable, which is not so in vegetable-culture except in special cases.

Again, the natural enemies of the oyster in the open waters of the Southern States are neither so plentiful nor so destructive as in northern localities, nor are the vicissitudes of seasons so apparent, causing destruction by freezing, ground ice, and severe storms, often entailing great losses upon those investing in the industry. The climatic conditions of the South are in favor of the speedy maturity of the oyster by promoting the culture of the diatoms and infusoria upon which they subsist. In fact, but one serious objection exists to the propagation of good oysters in all localities, and that is the extreme density of the water in which they abound, on the one hand, and a periodical drowning out by a superabundance of fresh water by excessive rainfalls in certain localities, on the other hand. Were these two extremes so modified, either by natural or artificial means, the coastwise territory of the Southern States would exceed in productiveness the output of the North, producing larger and finer-flavored oysters in the same space of time without the attendant suffering from the rigors of a northern winter.

Briefly stated, this can only be accomplished by utilizing our vast salt marshes and reducing the density, wherever required, by the use of surface water elevated by mechanical means, or the advantages obtained, if practical, by artesian wells to perform the same functions. Whether the sulphureted hydrogen usually present would prove detrimental, I am unable to state. I have been experimenting on that line for some time, but I can not say positively that it would prove injurious to the oyster in the quantities necessary to bring the salt water to the density required for its successful

culture. I am satisfied that the oyster will live even when exposed to undiluted artesian water, at half tide, but whether the propagation of the animalculæ which constitute the food of the oyster would be retarded, can only be decided after great experience and by extended research, and I therefore suggest that this feature be made the subject of experiments by experts of the U. S. Fish Commission.

I have during the past year been taking observations relating to the salinity of the water near the New Smyrna Inlet with a set of salinometers kindly loaned by the United States Fish Commission. These observations, recorded daily with few omissions, have been submitted to Washington, and from them we hope to ascertain the necessity of utilizing fresh water in artificial ponds or trenches to reduce the salinity. I have under construction at present an experimental area of about 1,000 square yards where the salt water can be diluted to any desired degree of density by the use of surface water, elevated into a tank of 10,000 gallons' capacity and shut off by a drain from the river. Personally, I believe this method to be the key to artificial oyster-culture, utilizing the coon oyster, everywhere present, for the purpose of planting. Though comparatively a novice in this important branch of food production, observation, experiment, and a diligent research into the practical experience of others have impressed upon my mind most forcibly that the field for further investigation is a wide one and prolific of good and profitable results to those who persistently and diligently labor therein.

## PROPAGATION OF THE SOFT CLAM.

Nowhere in the South do we find the soft clam, as known to the residents of the New England States. Among the Puritan fathers the clambake was an institution that brought into social relations the members of a community, and the waters bordering on the coast furnished the necessary products for these festive occasions. Down through succeeding generations the clambake has been and is now a time-honored institution, and is enjoyed by the residents of the coast and interior towns in near proximity to the ocean. The soft clam as an edible is far superior to the hard clam or quahog, and is also used for bait in the fishing industries of the section where it abounds. It is more fixed locally than the round clam and is much more prolific. On the southernmost shores of the Atlantic if at all present it is comparatively rare, and then occurs possibly only by being transplanted from its northern habitat. Our Florida lagoons and rivers, by reason of their shallow nature, abound in numbers of sand flats, exposed more or less at the various conditions of the tide. These could be profitably utilized for the culture of this desirable variety, which would prove a valuable acquisition to the locality, as well as a support to the inhabitants when once satisfactorily introduced. A preliminary consideration would be the necessity of protecting them from the depredations of parties having nothing but the present in view.

The soft clam has been introduced into the waters of the Pacific coast with the oyster, and has proved prolific and a desirable accession to the resources of that region. In referring to this branch of the shellfish industry it might be well to state to those having in charge these important problems of introducing the different varieties of fish, clams, etc., into new localities, that private enterprise is apt to labor under an immense disadvantage, by reason of unnecessary delay and carelessness on the part of the railroad companies during transit, and in many instances discouragement and disappointment follow. Were it not presuming unnecessarily, I would offer to plant and care for, to a certain extent, any consignment of soft clams for experi-

mental purposes and distribute them to suitable localities, if provision be made for their protection.

There is also a species of mussel that is indigenous to the salt marshes in the vicinity of New Smyrna Inlet. This mussel is not edible, but at times has been utilized for bait. The taste is of an astringent coppery nature and unfitted for consumption for the above reason. The edible mussel also might become a valuable acquisition to this section if it could be satisfactorily propagated.

## PROTECTION OF FISHERY INTERESTS.

The disadvantages that the State of Florida now labors under, by the reduced temperature experienced annually and the destruction of her valuable timber interests, without provision for renewal by the Government, necessitate the utilization of all available methods to develop her resources for the support of her inhabitants, and no better work can be done in this direction than to protect, to the fullest extent, the food-fishes and the oyster and turtle industries, including both the green and loggerhead varieties. The malicious slaughter of the female loggerhead should be punished to the fullest extent of the law, as well as the wanton destruction of fish by drag seines and gill nets. Since the law protecting the fish by preventing seining has gone into effect, the catch of sheepshead by hook and line has been greater than ever before, which makes the fishing-grounds about New Smyrna especially desirable for those who desire legitimate sport or those who rely on fishing for a livelihood. Heretofore the sheepshead were taken by hundreds in a drag net at night, which entirely eradicated in a short time the leading game fish in this vicinity. The same was largely true of the bass and trout. In these cases one or two persons monopolized the fishing business with drag or gill nets, and not infrequently the entire catch was wasted by no market or from lack of ice to ship. Nowhere in this section of the State is the fishing as good by line and rod as at this place at this time. Therefore, the protective clause in the fish laws of the east coast of Volusia County, Fla., has been productive of great good and should be continued, notwithstanding the efforts made to repeal it.

Of other prospective industries which might prove profitable, the propagation of the diamond-back terrapin, which abounds to a certain extent in the southern coast country, is suggested. The dissemination of knowledge by which the blue crab could be kept alive, in both the soft and hard shell condition, to enable it to stand transportation to a distant market, as well as practical information relative to the propagation of the stone crab (the lobster of southern waters), are subjects which deserve consideration. In the interior of the State are many ponds and lakes in which desirable fresh-water fishes could be successfully introduced, thus enhancing the value of those bodies of water and furnishing food and sport for many who are unable to visit the coast country for their supply of fish. A due consideration of these important subjects, resulting in effective effort, would greatly increase our food products and better the condition of the interior and coast country embraced in the waters of the Halifax and North Indian rivers of Volusia County, Florida.

NEW SMYRNA, FLORIDA.

# OYSTERS AND OYSTER-CULTURE IN TEXAS.

By I. P. KIBBE,
*Fish and Oyster Commissioner of Texas.*

The subject of oyster-culture is an old one, yet its importance demands our earnest consideration. While it has been agitated in Texas for many years, experiments have been limited, though small ones have been made which have proved profitable.

About the year 1890 the Galveston Oyster Company transplanted a large quantity of oysters, removing them from Matagorda Bay to Galveston Bay. It is reported that this effort proved a failure, and that they lost not only the plant but also the spat of that season. The total destruction of this bed has never been satisfactorily explained, though several theories have been advanced—a mud deposit from the Gulf, drainage from the creosote works at Galveston. Another plausible theory is that the bed was maliciously destroyed by persons opposed to the enterprise. The fact that oyster-beds in the same bay, less than 10 miles from this bed, were not injured in any way, points to the latter conclusion.

While this experiment was unsuccessful, it is no proof that oysters can not be cultivated in Texas as well as elsewhere, for it is a fact that they have been profitably cultivated in a small way in this State for more than forty years. These results were obtained by transplanting in the spring into bayous, channels, or coves, which offer a better supply of food than the natural reef or bed. Oysters handled in this way grow much larger, fatten sooner, and bring much better prices in the market.

The Tiger Island Oyster Company, of Port Lavaca, Texas, planted over 4,000 bushels of seed oysters in March, 1897, and in November these oysters were in fine condition. More than one-fourth were average-size, marketable oysters, which, if left on the reef, would not have been utilized at any time, as oysters from this reef had not been found in a marketable condition for years. The price of transplanting being less than 15 cents per barrel and the market price of good oysters being from 75 cents to $1.25 per barrel, a good margin is left for the work of gathering and marketing.

It is claimed by some that oysters will grow in almost any locality and upon any bottom, a collector for the spat being the only essential. While this is true to some extent, my observation does not bear out this theory altogether. Food supply, as well as a limited amount of fresh water, are necessary elements. While they do well on some mud bottoms, on others they die as quickly as on sand. A deposit of foreign soil or mud will often kill out a bed, although a good bed will sometimes be entirely surrounded by a natural mud bottom. I am of the opinion that many failures can be attributed to this cause.

In changing oysters from one locality to another, depth and temperature of water should be observed as well as other natural surroundings. If any great change is necessary, it will be found that the young oysters will stand it much better than the grown.

Regarding the best artificial bottoms and collectors, I would say that these depend entirely upon the original bottom. If in deep mud and but little or no current or sea, brush, brush mats, old shoes, and leather can be used. If in current or sea, the mats would have to be anchored and the brush stuck in the bottom as a stake. Upon hard bottom oyster shells are considered the best and cheapest collectors, but will not do in soft mud unless fine shell be used as a foundation. In the planting of oysters, as in other things, the nearer we approach nature the more certainty there is of success.

Owing to the mildness of the climate and long growing seasons in this State, the oyster is very prolific. The spawn being less liable to injury from cold, a good spat for each year is more certain.

Many inquiries are made as to the maturity of a marketable oyster. Under favorable circumstances some mature in three years from the spat, but four years will ordinarily produce a good marketable oyster where favorably located on any part of our coast.

In this State the oyster has but few enemies, the drumfish being the only one dreaded. There are no starfish and but few worms or conchs.

Our present law gives to any citizen of the State the right of locating as much as 50 acres of land covered with water for an oyster-bed. The locator pays a surveying fee of $10 and a rent of 10 cents per acre for the first five years and 25 cents per acre thereafter. As long as the rent is promptly paid he is amply protected. He is allowed to gather seed oysters from certain reefs for planting without culling.

We have along the coast of our State about forty bays, lakes, and coves. But few if any of these are without a natural oyster-bed. Hence, there is no lack of seed oysters within easy reach of good grounds.

The above facts, with the climatic advantages and over 300 miles of coast, enable Texas to offer inducements in the oyster industry equal if not superior to any other State in the Union.

PORT LAVACA, TEXAS.

# THE METHODS, LIMITATIONS, AND RESULTS OF WHITEFISH-CULTURE IN LAKE ERIE.

By J. J. STRANAHAN,

*Superintendent of United States Fish Commission Station, Put-in Bay, Ohio.*

In a paper of this character it will not be possible to go into details as to the methods pursued in whitefish-culture, nor do I deem it necessary, since the subject has been so often and so ably treated; but I will rather confine myself to what I conceive to be some comparatively new and interesting features of the work.

To summarize, it is only necessary to say that the mode pursued at the Put-in Bay station of the United States Fish Commission is the same as that generally followed, dry impregnation being the starting point—that is, the eggs and milt are brought into contact as they come from the fish and well mixed, after which water is added, the mass gently stirred and allowed to stand about 2 minutes, when the eggs are washed and placed in wooden kegs holding 15 gallons each.

In this connection it will be proper to state that a series of experiments made at Put-in Bay station the past season demonstrates that in water the milt loses much of its vitality at the close of 1 minute. In fact, at the close of ½ minute it has done its best work. In one test only 49 per cent of the eggs were impregnated by milt which had stood in water 1¼ minutes, and in another 47 per cent where it had been 1½ minutes in the water; while eggs from the same lot showed 98 per cent and 97 per cent impregnation, respectively, where milt was used from the same lot which had stood but ¼ minute in the water. It is therefore obvious that reliance should not be placed in milt which has stood over 1 minute in water, and it follows that eggs should be washed at the close of 2 minutes, as the longer they stand in the milt after impregnation has taken place the worse for the eggs, as shown by Professor Reighard and other writers.

After being brought to the station, some 2 to 10 hours after taking, the eggs are kept in the kegs in running water and carefully stirred once an hour until the next forenoon, it being our belief that while "harding"—that is, while the investing membranes are filling with water—they should not be submitted to even the gentle motion which they undergo in the jars.

It is evident to all observant fish-culturists that the eggs must be treated in the most gentle manner possible from the time they are taken up to the period when they are sufficiently cushioned by water to protect them from injury.

As is well known, many whitefish and lake-trout eggs are annually lost through lack of males at certain times, especially near the close of the season, when large numbers of ripe females are taken from the nets with very few or possibly no males. With this fact in view, experiments were made at Put-in Bay the past season to demonstrate practically how long the milt and eggs can be held separately and still

retain their fertility. It was shown beyond question that both may be held at least 48 hours, and practically as great a percentage of impregnation procured as if applied immediately after they are taken from the fish.

I will quote from the records of the station the results of a few experiments which will fairly illustrate the whole. One lot of eggs taken on December 6 was impregnated on December 7 with milt taken on December 4; percentage of impregnation, 98. A lot taken on the same day and impregnated immediately with milt just taken showed the same percentage of impregnation—a mere coincidence so far as exactness is concerned. Another lot, where the spawn and milt were both taken on December 6 and impregnated on the 7th, showed 97 per cent impregnated. Still another lot taken on the 7th and immediately impregnated with milt taken on the 4th showed 95 per cent impregnation. Fourteen tests were made, and it may be inferred from them that neither the eggs nor milt can be carried past the third day with good results. With all those carried past that time the percentage of impregnation ran from 0 up to 6.

In this work care was taken that the eggs and milt should be kept entirely free from water and other foreign substances. The eggs were held in pans and the milt in corked vials, both being kept in running water at the then prevailing temperature of the lake—about 35° F. One lot of milt, where a very small clot of excrement had entered the vial, was used as an experiment 48 hours after it was taken and failed to impregnate any eggs.

One of the important problems in whitefish-culture in Lake Erie has been the successful penning of adult fish in order to hold them until their eggs are sufficiently developed or ripe. Up to the past season this has been a failure so far as practical results are concerned, for the reasons that the pound nets are so scattered and so few fish are taken from each on each day that under the usual methods sufficient fish could not be procured, and that when penned in stationary inclosures in landlocked bays—the only place where the crates can be held during stormy weather—the water, during specially warm periods, gets so warm as to render the fishes unhealthy and the eggs become congested, or what is called "caked," in the abdomens of the females. Both these causes have been removed at Put-in Bay station the past season.

A supplemental net 3 feet in diameter and 7 feet long, held open at the top and bottom by iron rings, is placed at each pound net by fastening one side to the down-haul stake and the opposite to the rim line of the pot, thus holding the top about 3 feet above the surface of the water. When the pound is lifted all the whitefish are singled out and lifted by a net made of coarse, open cloth—an ordinary net is too harsh on the fish and injures their delicate scales and fins—and dropped into the supplemental net, from which they are taken and placed in special tanks on the deck of the station steamer and removed to the crates located near the station. It will be readily understood that by this means the fish can be procured from a large number of nets, while otherwise only such can be saved as are procured by one lifting boat, accompanied by the steamer, as all the boats in a given locality lift at about the same time, generally early in the morning. After the fish are in the supplemental nets they can be collected by the steamer at leisure, taking all day for it if necessary.

To avoid the danger of too warm water the pens or crates are secured between long pine-boom logs, the whole making a substantial raft, which can be towed outside and anchored where good currents and safe temperature can be procured until danger is past. The crates are surrounded on all sides by walks for convenience in sorting and handling fish. The compartments of the crates are 8 feet square and 7 feet deep,

ith false bottoms guided by upright standards used in raising and lowering the lse bottoms for the better examination of the fish. Each compartment will carry bout 250 fish at a time, or about twice that number during the season, as the numers are continually being added to and taken from, as new arrivals come in and the lder ones are stripped and sent to market.

The fish are sorted into three classes, which are denominated soft, medium, and ard, and are handled as little as possible. The softs are examined the next day after eing sorted, the ripe ones stripped, and the others reclassified if necessary—the ıediums on the third day and the hards in about a week, it having been found by xperience that very little spawn is lost by thus holding and very much unnecessary andling is obviated.

Although large numbers of fish were not penned at Put-in Bay the past season, wing to almost continuous gales, the experiment proved a complete success, as showıg what can be done in an ordinary season. Over 10,000,000 eggs of good quality ere taken, and it should be remembered that but for the penning the eggs would ave gone to market in the abdomens of the fish and been lost. The fish, notwithtanding the adverse circumstances under which they were taken, did remarkably ell, and only seven were lost because of becoming diseased, and they had been ıjured in the pound nets before coming to our hands. The last fish turned over to ıe fishermen were in as fine condition as if just taken from a pound, and some of ıem had been in confinement for a month.

As to the limitations and results, they must be largely a matter of speculation. Vith penning successfully carried out there would seem to be practically no limit to ıe number of fry which can be turned out, and then comes the question, To what extent the hatching of whitefish beneficial? The statistics do not answer the question in a anner entirely encouraging to the fish-culturists, and yet I believe I am safe in ıying that there is not a commercial fisherman on Lake Erie who does not think that ıe hatcheries have done much to increase the take of whitefish, many of them openly serting that but for the work of artificial propagation whitefish would be practically tinct in the lake. They cite in proof of this that while the increase has not been hat they might hope, the whitefish has reasonably held its own, while all other ımmercial fishes have rapidly fallen off.

There is another encouraging feature to be noted. If common report is to be ken for anything, the catch of whitefish has been greater in Lake Erie the past ason than for several years past. This is especially the case with the gill nets in ep water, also with the pounds at the head of the lake, so the writer is informed ı what seems to be trustworthy authority. Of course it is too early yet to have liable statistics as to just what the catch was. The fish were small and of quite ıiform size, which lead the fishermen to the conclusion that at least a considerable ortion of them were the result of the large hatch of the season 1895–96, when 21,000,000 fry were planted in Lake Erie from Put-in Bay station, and when the etroit hatchery of the Michigan Fish Commission and the Sandwich hatchery of ıe Dominion Government of Canada made specially large plants, all of which found ıeir way into Lake Erie.

In common with other fish-culturists the writer believes that the work of artiicially increasing the number of whitefish in Lake Erie and the other waters to hich this fish is indigenous will be greatly improved when some practical way is

found for holding and feeding the fry, if only for a few weeks, or until they are large enough to care for themselves. Nor do we believe that such a hope is wholly illusory, for the experiments of Mr. Carl G. Thompson, of Warren, Ind., who succeeded in rearing this fish from the fry in considerable numbers in comparatively small ponds by feeding them on fine wheat middlings, at least gives encouragement that the problem will yet be solved. It is true that experiments at feeding whitefish fry at Put-in Bay the past season were not successful, but the work is new and it may yet be brought to a successful termination.

## MORTALITY AMONG FISH EGGS.

As is well known to fish-culturists, there is a considerable mortality among fish eggs between the stage where the embryo is formed and the time of hatching. Can this be prevented? To answer this question intelligently we must first know the cause, and to this end I have carried on a series of investigations, making them as thorough as I could with my very limited knowledge of the several sciences called into action and the appliances at hand.

Dead and dying eyed eggs, generally easily detected by the naked eye, were examined from time to time, generally in hundred lots, and where the cause of loss could be determined the results were kept in memorandum. In many cases the cause is easily ascertained; in other cases, with my limited knowledge, it could not be determined at all. I should here state that, having no microtome, all the work was done in gross, simply by the aid of the microscope, and that without doubt one well versed in the work and with suitable instruments could determine the cause of death in a large percentage of those where I failed. I should also state that the percentages here given are not absolute, for the reason that with dead eggs considerable numbers were in such a condition that no opinion could be arrived at, although if examined a little earlier the cause might have been apparent, and in the case of aneurisms and ruptured blood vessels most of them were discovered while examining apparently healthy eggs, the embryo being not yet dead but dying, and the egg therefore not yet so changed as to be detected by the unassisted eye.

By far the greater loss of the whitefish eggs in embryo, the only ones examined, is caused by insufficient food supply, the yolk being undersized, and when the store is exhausted the embryo dies of starvation, this occurring at all stages from the early formation of the embryo up to the time of hatching, those with very small yolks dying first and others later on. Taking an average of all my data, this amounts to 31 per cent of the total loss of eyed eggs, but for reasons already stated this is not strictly accurate, and I am of the opinion that it is too low rather than too high.

The next greatest loss is caused by abnormal development, and here I am less certain of my percentage than in the former case, for the reason that the diagnosis is more difficult to the unscientific eye. It may, however, be safely stated that the loss is not far from 20 per cent, and extends over the whole period of incubation up to the time of hatching, and doubtless far beyond.

In some cases there is not the semblance of an embryo, and yet life goes on up to a certain stage. The cell mass spreads out over the yolk in an irregular way, perhaps a brain and a heart forming with a rudimentary spinal column, while in other cases the egg dies before any of the organs are discernible. I have never observed eyes in any of these more imperfect ones; in fact, the eyes are among the organs first to show abnormality, while crooked spines are well-nigh universal. Often one of the eyes rudimentary or missing entirely, and sometimes both.

Twins and double-headed monsters, common with trout, are so rare with the whitefish that I have discovered but few, except in the case of the eggs of a single fish, where they amounted to over 10 per cent of the whole.

Next come aneurisms and ruptured blood-vessels, probably between 5 and 7 per cent. Aneurisms are much more common than ruptures, and, contrary to the rule with the higher animals, they cause death without the complete rupture of the artery. The red corpuscles form a clot in the enlargement, the serum filtering through the mass, and only a straggling red corpuscle being seen here and there coursing through the vessels of the body. The clot seems to collect them all. The heart beats feebly, and death ensues. Aneurisms are most common in the side of the embryo about the middle of the body, and it seems that most of them are on the right side.

In the earlier stages, that is, up to about two months from the taking of the egg, there is a small loss occasioned by the rupture of the yolk-sac. In these cases the embryo generally lives a few days after the rupture. I have not computed this loss very closely, but it does not probably exceed 1 or 2 per cent.

In all these cases, where the embryo is far enough advanced to show the pigment cells, or "color stars," and is approaching death, the branches of the cells become shortened, and usually at death only the nucleus remains.

For the remainder, I have not been able to determine what is the cause of death. In many cases I find what seem to be small patches of a fungoid growth on the body of the embryo. I can not see that they do any harm, and have not discovered them on the bodies of dying embryos more than those in an apparently healthy condition.

It seems to me that these deaths are the result of the natural weeding out of the weakly individuals, "the survival of the fittest," the same as in the higher forms of life, and that no amount of care on the part of the fish-culturist can prevent it, except, possibly, in reducing the number of abnormalities by exercising great care in the taking and handling of the eggs, eminent biologists holding that monstrosities are often caused by injuries sustained at certain stages in the development of the individual.

In this connection I would state that, so far as my observation goes, this loss of eggs after the embryo is formed varies greatly from year to year. It is also certain that eggs taken near the close of the season suffer a greater loss in this respect than those taken at the flood. With eggs taken near the close in small lots this loss may amount to a fourth of the whole, or even more.

PUT-IN BAY, OHIO.

# A BRIEF HISTORY OF THE GATHERING OF FRESH-WATER PEARLS IN THE UNITED STATES.

By GEORGE F. KUNZ.

The gathering of pearls from the fresh-water shells of North America, although a matter of comparatively recent date among the present inhabitants, really goes back very far into the unrecorded past, and early attracted notice among the first European explorers. In the prehistoric period the mound-builders of the Mississippi Valley gathered immense quantities of these pearls, as is amply shown by the stores of them found on the "hearths" of a number of mounds, especially in Ohio, by the recent explorations of Prof. F. W. Putnam and Mr. W. K. Moorehead. By age, burial, and in some cases funeral or sacrificial fires, these pearls have lost their luster and beauty; but they were evidently highly prized by these ancient people and gathered by the hundred thousand. The finding of two bushels in a single series of mounds is an evidence of their abundance.

The first explorers who traveled among the Indian tribes speak frequently of the number and beauty of the pearls in possession of the natives. Especially marked are these accounts in connection with the great expedition of De Soto, from Florida through the present Gulf States to Mississippi, in 1540–41. Garcilasso de la Vega and other narrators give minute accounts of pearls as worn by the Indians; and from the accounts given by them to De Soto at various times, and as taken by the Spaniards from burial-places of native chieftains, it is quite evident that perhaps all of these referred to were not marine, but fresh-water pearls. De Soto's narratives, which undoubtedly referred to the latter, seem exaggerated, but the recent finds substantiate them. The process is described, moreover, of gathering the shells and opening them by heat, which was shown to De Soto, at his request, by a friendly chief. In the same way several early English travelers, from New England to Florida, refer to the Indians as having pearls, undoubtedly from the fresh-water Unionidæ.

No particular attention, however, was given to the subject until about forty years ago. The natives had been dispossessed, and the white race, occupied with other interests and necessities, took little note of the hosts of fresh-water shells inhabiting the streams and lakes, and did not suspect their power of producing pearls. In the rivers of Saxony and Bohemia, indeed, and those of Scotland and Ireland and the lakes of Finland, such pearls have long been known and valued, although Unio life is far less abundant there than in our great river systems of America; but not until the middle of the present century was a search begun or any important discovery made.

NOTE.—This article is chiefly an abstract of a more comprehensive report on pearls by the same writer, which will appear hereafter in this volume. The present paper was prepared for the Fishery Congress by special request, for the purpose of calling the attention of delegates to the latent resources, in many parts of the country, in pearls and pearl-bearing shells.

This was all changed, however, by the first great pearl excitement in 1857, when large and valuable Unio pearls were first obtained in New Jersey. First, a pearl of fine luster, weighing 93 grains, was found at Notch Brook, near Paterson. It became known as the "queen pearl," and was sold by Tiffany & Co. to the Empress Eugenie of France for $2,500. It is to-day worth four times that amount. (See colored plate No. 8, Gems and Precious Stones of North America.) The news of this sale created such an excitement that search for pearls was started throughout the country. The Unios at Notch Brook and elsewhere were gathered by the million and destroyed, often with little or no result. A large, round pearl, weighing 400 grains, which would doubtless have been one of the finest pearls of modern times, was ruined by boiling to open the shell. Within one year pearls were sent to the New York market from nearly every State—in 1857 fully $15,000 worth. In 1858 it fell off to some $2,000; in 1859, about $2,000; in 1860, about $1,500; in 1860–63, only $1,500. The excitement thus abated until about 1868, when there was a slight revival of interest, and many fine pearls were obtained from Little Miami River, Ohio.

Some of the finest American pearls that were next found came from near Waynesville, Ohio, $30,000 worth being collected in that vicinity during the pearl excitement of 1876. Since 1880 pearls have come from comparatively new districts farther west and south, the supply from which is apparently on the increase. At first few were found, or rather few were looked for, west of Ohio; but gradually the line extended, and Kentucky, Tennessee, and Texas became the principal pearl-producing States, and some pearls were sent north from Florida.

A few years later the interest extended to the Northwestern States. During the summer of 1889 a quantity of magnificently colored pearls were found in the creeks and rivers of Wisconsin—in Beloit, Rock County; Brodhead and Albany, Green County; Gratiot and Darlington, Lafayette County; Boscobel and Potosi, Grant County; Prairie du Chien and Lynxville, Crawford County. Of these pearls, more than $10,000 worth were sent to New York within three months, including a single pearl worth more than $500, and some among them were equal to any ever found for beauty and coloring. The colors were principally purplish red, copper red, and dark pink. Within the past eight years probably over $200,000 worth of pearls have been sold from this district.

These discoveries led to immense activity in pearl-hunting through all the streams of the region, and in three or four seasons the shells were almost exterminated. In 1890 the search extended through other portions of Wisconsin, especially Calumet and Manitowoc counties, and also in Illinois, along the Mackinaw River and its tributary creeks, in McLean, Tazewell, and Woodford counties.

In 1889 the exhibit of American pearls received an award of a gold medal and the collaborateur a silver medal for the literature. At the Columbian Exposition at Chicago, in 1893, large and beautiful exhibits of pearls of great variety of tints, set in the finest jewelry, were exhibited in the Manufactures building, and formed notable features in the Wisconsin State building and the Mines building.

The northwestern pearl excitement subsided in a few seasons, as the others had done in turn before, by the exhaustion of the mussel beds and the consequent cessation of product. About every ten years or so a new wave of interest arises in connection with fresh discoveries at some point where the shells have lain long undisturbed; it again absorbs the attention and excites the imagination of the community

around and spreads to other parts of the country; a fresh campaign of ignorant extermination is carried on for several summers, then the yield is exhausted, and there is nothing more but to leave nature to recuperate, if possible, and slowly to restore, in limited amount, the abundant life that has been destroyed.

During the season of 1897 the pearl fever has broken out in various parts of the country, the particular scene of discovery and excitement being the hitherto undisturbed streams and bayous of Arkansas. These waters teem with Unios, and pearls have at times been found by the rural population for years past; but there has been, usually, no knowledge of their nature or their value. They have been simply regarded as "pretty stones," and used as playthings by the children—like the first South African diamond, that attracted the notice of a trader in 1866 as he saw it in the hands of the children of his Boer host at the Vaal River.

Several valuable pearls, however, were this year found by persons from St. Louis and Memphis, who at once sent them to those cities and ascertained their reality and value. The same parties then searched for more, and took steps to lease the land where pearls were found abundant. Ere long the facts became known, and a wild excitement set in and spread through large portions of Arkansas, extending into Missouri, Kansas, and the territory of the Choctaw Nation. The first important discoveries were on small lakes or bayous, formed by affluents of the White River, in White County. The subsequent activities prevailed along the general valley of White River and its branches, then on the Arkansas, the Ouachita, and the Black, Cache, and St. Francis rivers, thus affecting almost all sections of the State. In one district an entire lake was leased, guarded, and fenced for its pearl contents alone.

The newspapers took up the subject and published highly sensational accounts of the treasures to be had in what was largely proclaimed as "the Arkansas Klondike." These articles were copied all over the country, and led to a great amount of pearl-hunting in many States, both east and west. Iowa, Tennessee, Georgia, New York, and Connecticut were all more or less stirred up to activity. The former pearl region of Tennessee was less affected than a new section in the eastern part of the State, along Clinch River, where great crowds have been searching for pearls, and large quantities were obtained. The Georgia interest has been chiefly along the Oostenaula, near and above Rome. The New York activity has been in the northwestern angle of the State, along Grass River, in St. Lawrence County. Connecticut has yielded some good results to the searchers on the Mystic and the Shepang rivers, at almost opposite ends of the State.

### REASON FOR THE PEARL INVESTIGATION.

In view of the great interest and possible importance of discoveries from time to time made in various parts of the United States, particularly in the Mississippi Valley, of pearls yielded by the fresh-water bivalve shells (*Unionidæ*) so abundant in many of our inland waters, I was invited, in 1894, to undertake a systematic inquiry, for the United States Commission of Fish and Fisheries, to ascertain, as far as possible, the facts relating to the occurrence and distribution of the pearl-bearing species, and the extent and conduct of the pearl industry as thus far developed. The value and elegance of many of the pearls, especially as shown in exhibits made at the Columbian Exposition in 1893; the popular excitements or "pearl fevers" at times arising in districts where a few pearls have been found, and characterized by whole-

sale and reckless destruction of the shells over large areas; the total lack of system in the search for pearls, as contrasted with the methods that have been developed on a smaller but far more profitable scale in Europe, all seemed to call for a careful investigation by the Commission, with a view to better knowledge and wiser direction in the matter of inland American pearl fisheries.

Undoubtedly, for a considerable period after the first explorations, the pearl resources of North America seem to have attracted little attention. The Indian race was contending with the whites for the possession of the country; it was a time of uncertainty and strife for both races; and not until the great waterways of the Mississippi Valley had been won by the whites, the region occupied, and settled communities established, do we again begin to find any indications of the search for fresh-water pearls. For some two centuries the Unios lived and multiplied in the rivers and streams unmolested by either the native tribes that had used them for food, or the pioneers of the new race that had not yet learned of their hidden treasures of pearl.

It is with some surprise that one notes that so few American conchologists have paid attention to our native pearls. It is probably accounted for by the fact that the pearls are contained in old, distorted, and diseased shells, which are not so desirable for collections as the finer specimens. Collectors who have opened many thousands of Unios have never observed a pearl of value. Pearls are usually found either by farmers, who devote their spare time to this industry, and if no result is obtained suffer no loss, or by persons in country villages who are without regular occupation, but are ever seeking means for rapid increase of fortune. Multitudes of shells that do not contain pearls are destroyed in the search.

## HABITAT OF THE FRESH-WATER MUSSELS.

From the many inquiries sent out, the general indications from the answers are quite plain, to the effect that the shells are chiefly found in rather rapid streams, in which the bottom would naturally be sandy or gravelly and the water clear. Other species, however, occur on muddy or clayey bottoms, where the current is slower. The references to rock bottom do not concern so much the immediate surface where the shells are found, as the underlying bed on which the softer materials rest. In the matter of depth, also, the large preponderance of answers in favor of shallow streams may mean, not so much that the Unios greatly prefer shallow water, as that they are more readily found and gathered there. The frequent allusions to "hard" or calcareous water seem to confirm the general impression that streams of this kind are favorable to the development of molluscan shells, both in size and in abundance, and the greater proportion of calcareous matter in the water tends to induce the prolific secretion of the pearls.

A Florida writer states that the best Unio growth is found in lakes with outlets, the water pure and fresh; but adds that it is sometimes sulphurous. A Texas pearler (Colorado, Concho, San Saba, and Llano rivers) refers to the water as becoming slightly alkaline in dry times; and another Texas pearler (Colorado and Llano) makes a similar statement. A New York pearler (De Grasse River and Plum Brook) mentions the water as brown or black—the clear, brown water of the hemlock districts, familiar in northern New York.

The general conclusions most clearly brought out may perhaps be summed up as follows: The shells are most abundant in swift and clear water where the bottom

sandy or gravelly and the country rock calcareous. While still numerous in many streams, they have greatly diminished within a few years past, wherever the pearl-hunting enterprise has extended, and are at some points nearly exterminated. The pearls found are few, and those of marketable value represent the destruction of thousands of shells for every one obtained. No use is made of this often beautiful material, which is simply thrown away and lost; although for buttons and ornamental articles it would be admirable. The methods of gathering the shells and extracting the pearls are the simplest and most primitive, and the activity of a few seasons generally exhausts the beds.

This state of affairs is one that calls loudly for reform. The wealth of Unios that filled our rivers is rapidly being destroyed by ignorant and wasteful methods of pearl-hunting; and either some form of protection is important, or, if that be not possible, a wide diffusion of information as to better methods, and particularly the introduction of tools used in Germany for opening Unios far enough to see if there are pearls contained without destroying the animal, which may then be returned to the water.

### PEARL-HUNTING AS AN OCCUPATION.

As to the principal occupations of the pearl-hunters, or pearlers, as they are called, this was answered by 64 papers. Of these, 13 say merely that their occupations are various, or that people of all callings are included. The remaining 51 papers state more or less definitely as follows: Farmers and farm-hands, 23; laborers, 12; fishermen, 8; and as making pearl-hunting a regular business, 7. Three papers speak of loafers, and one or two each specify as follows: Stockmen, hunters, trappers, tradesmen, roustabouts, boys, and negroes, and the Maryland paper, oystermen. The term "laborers" as used in those answers probably means, in most cases, farm-laborers, as stated in a few instances; and the indication is that two-thirds of the pearl-hunting is done by agricultural people who search the streams when not otherwise occupied, "in off times," as two or three of the writers say. Fishermen are naturally much in preponderance, who gather the mussels for bait.

### METHODS OF EXTRACTING PEARLS.

The inquiry as to the mode of extracting the pearls when found received 72 answers. A large proportion of these are general, merely saying "by hand," "with the fingers," etc., but about one-third give more or less description of the process. When the shell has been opened, the pearls, if loose and near the edge, may be readily seen, and sometimes even drop out. These are, of course, easily taken out with the thumb and finger, or, if small, with tweezers, or on the point of a knife. If more imbedded in the mantle and gills, they are detected by feeling for them, passing or rubbing the thumb or finger along and around each valve and about the region of the hinge. The pearls may then be pressed or squeezed out "like the seed of a cherry"; but if attached to the shell, must be removed with a pair of nippers. Care is required in opening, not to scratch or injure the pearl. A very few describe different methods; thus one Arkansas pearler speaks of breaking the shells, and a Florida pearler tells of piling the mussels in a dry place to decay, the Oriental method of opening the true pearl-oyster and finding the pearls in the emptied shells later. This method is evidently practicable only where little or no "pearl hunting" is generally carried on, and the pile of shells would not be liable to inspection and search by other parties than the original gatherers.

### TREATMENT OF PEARLS WHEN FOUND.

Concerning the treatment of pearls when found, definite answers were received in 52 papers, which, in some respects, show considerable diversity of usage. The pearls are first thoroughly washed to remove all adhering animal matter, and two papers speak of using alcohol to complete the cleansing. After this the essential point in keeping or carrying them is to prevent injury to the surface from friction, and the majority of those who describe what is done tell of wrapping in cotton, or soft paper, cloth, flannel, or silk. Several speak of drying them, or keeping them dry. But others would keep them in a liquid, six specifying a bottle of water and one sweet oil or coal oil. Several speak of putting them into a bottle, but with no account of its contents, or whether even dry, though an Indiana paper mentions cotton in a bottle, and hence, in the cases just referred to, it is impossible to judge as to what is the probable meaning. Two papers mention keeping pearls in starch, and one "in Irish potato." The effect of sunlight is curiously alluded to by two papers, one stating that pearls should be kept from it, and the other that they should be kept in it.

Six Tennessee papers make interesting references to "peeling" dull and unpromising pearls, merely saying that this is sometimes done "with a sharp knife," and a nice pearl obtained thereby. Alcohol, whiting, chamois leather, etc., are mentioned as employed to produce a good surface of luster. Two other papers allude to polishing or cleaning pearls, one specifying that it is done "with Irish potato." Two papers say nothing under this head, save that there is no way to improve nature.

### DESTRUCTION OF THE MOLLUSKS.

As to what, if any, use or disposal is made of the shells after being examined for pearls and the animals destroyed, the papers give a painful record of the utter waste of an enormous amount of material valuable for many purposes in the arts. The question is answered in 74 papers, with a melancholy uniformity. In only 12 of them is there any suggestion of utilization of the shells, and in only 1 of the use of the animals other than as fish-bait, manure, or food for hogs. Twenty-six answers say simply that there is no use made of them, or that they are "wasted" or "thrown away"; 9 say that they are thrown in the water, and 6 add that the fish eat them and also the muskrats and tortoises; 7 speak of their being used for fish bait; 6 for feeding hogs, and 2 for manure. Several merely say that they are left on the banks or shoals for rats, minks, and crows to dispose of.

An Iowa pearler states that the shells are utilized for button-making, and that some people use the animal for soup. The actual use of the shells for buttons is also referred to by two pearlers, and their possible value for that purpose is noted in four other papers, though they are not so used as yet. One says that a few are polished for ornamental purposes, and another makes a similar statement, adding that they are also used to pave garden walks and burned for lime. This latter use, for lime, is referred to also by three Tennessee papers as actual or possible, and one says that they might be "ground to cement," and one Wisconsin writer notes that some are ground up for poultry.

### AS A FOOD PRODUCT.

There would seem to be a strong presumption that the mound-builders must have used the Unios quite largely for food, as we know that the later Indian tribes did, as will be referred to further on. They naturally were thus led to the finding of pearls,

and accumulated large stores of them in the course of time. The ancient tribes of Brazil have left shell heaps along rivers tributary to the Amazon, composed of fresh-water shells of that region (Hyria and Castalia); and though no such stores of pearls have been found, yet the shells themselves have been much employed as ornaments among these people; so they also were in the United States.

When it is remembered that the native tribes of both North and South America made large use of the river mussels as an article of food, it seems extraordinary that only one instance of any attempt so to utilize them should appear in these accounts; although Canadian lumbermen catch them by allowing bushes to drag after their rafts in shallow streams, using the mollusk for food. They could, perhaps, often save life, if explorers or hunters knew of their existence; while the shells, which are so capable of being wrought and polished into an immense variety of beautiful objects of ornamental art, should command a remunerative price, instead of being thrown away and wasted. The small ones are often as brilliant as an opal in color.

## UTILIZATION OF UNIO SHELLS FOR BUTTONS.

Several references, from time to time, have been made to the valuable possibilities of the abundant shells of the Unios for various purposes of manufacture, and some few instances noted of their being polished as ornaments or cut into buttons. It is highly interesting to learn that this latter use has at last attracted attention and is developing into an important industry. A correspondent of the St. Paul (Minn.) *Dispatch*, under date of November 13, 1897, gives an extended account of the shell-button manufacture at Muscatine, Iowa, where already a number of factories are in operation. No dates are specified; but the statement is made that it was begun within a few years past by Mr. Boepple, a German, who recognized the possibilities of such an industry and established a factory at Muscatine, soon employing 200 operatives, besides a number of outside people gathering shells from the Mississippi River at that point. The enterprise proved profitable, even under an unfavorable tariff, and several other factories were established; but since the recent protective legislation has gone into effect the business is increasing largely. Eleven or twelve factories are now in operation, running 300 saws and employing 1,500 people. One of these was working on double time to fill orders for 20,000 gross of buttons for the "holiday trade" of 1897. The business is already an important element in the prosperity of the town; and as the supply of shells is enormous, it is expected to increase in extent. Other works exist also in Iowa. There are also eastern factories referred to that cut the shells into "blanks," i. e., unfinished disks, and send them to Muscatine to be polished and perforated.

The shells have been gathered by men and boys wading in the shallow water and working from boats in the deeper parts with rakes provided with a wire net or basket. Now, however, steam dredging is to be employed. One such boat has been built and another is under construction. The dredge will take up a ton of shells in an hour, and the steam will be used to cook the animals and clean the shells—a process now slowly conducted in small furnaces. As the gathering can not be carried on in winter, when the river is frozen, prices rise in autumn. Several species are capable of being used, of which two are particularly mentioned; these are "nigger-head" shells, which have risen with the approach of winter from 35 cents per 100 to 70 cents, and "sand" shells have advanced correspondingly from $1 to $2 per 100.

### PRESENT ABUNDANCE OF FRESH-WATER MUSSELS.

Out of 83 papers which respond to this inquiry 7 describe the shells as at present very abundant; 36 as plentiful; 25 as scarce, and 3 as absolutely exterminated; 28 papers refer to the fact of diminished and diminishing numbers within a few years past, some of them with great emphasis. Three of the Tennessee papers estimate the numbers as reduced to about one-tenth of what they were ten years ago, and the same general fact is stated, of former abundance and present rarity, and attributed to the pearl-hunting destruction of a few years past. Several papers say that the shells are now scarce in small streams and the shallower parts of larger ones, while still abundant in deep water and where the currents are strong.

### NATURAL ENEMIES.

In regard to natural enemies, 84 papers are varied and interesting, and in some respects quite contradictory. The chief natural enemy of the Unios appears to be the muskrat; 65 papers refer to it, 26 reporting large destruction from this cause, 38 in some degree, and one denying any. Hogs come next, and are referred to in 47 papers. Of these, 7 hold them responsible for large destruction, 35 for some, or a little, and 5 assert that there is none. Of other animals, raccoons are stated, in 13 papers, to destroy some shells; mink in 5; mud turtles in 3; crawfish in 2; aquatic birds in 2; and cattle, by trampling, in 3. All the animal depredators deal only or chiefly with Unios that are either young, small-sized, or soft-shelled, and hence not largely pearl-bearing. The only exception to this general rule is the statement in one paper that many pearls have been found where shells had been taken ashore by muskrats and left to open in the sun.

### INJURIES DUE TO PHYSICAL CAUSES.

With regard to physical causes of injury, the most serious, no doubt, is found in freshets. Of 31 papers that refer to these, 17 report great destruction thereby; 13 say "some" or "a little," and 1 denies that there is any. Some papers say that their injury is small, and that they only shift the beds and redistribute them; but a number describe the burying of beds by the washing down and caving in of banks in flood-time, or the stranding of great quantities of young shells when the water subsides. Two papers that do not mention freshets should doubtless be included here, however, as they speak of destruction caused to the shells by "covering with mud," and by "change of bars." On the other hand, low water and droughts are reported as seriously harmful in 5 papers, and drift ice in 3. Two papers allude to disease as a cause of injury, and 3 to boring parasites.

### EXTERMINATION OF THE MOLLUSKS.

The question as to exhaustion of the mussel-beds, its causes and its rapidity, has called forth a very suggestive body of replies in 57 papers; the remaining third make no response, or none that is at all definite; 9 papers report extermination of the shells, either actual or imminent, within a very few years past; 20 speak of rapid diminution in their numbers; 16 of decrease as noticed and in progress; 8 are uncertain or report little or no change; 6 describe them as abundant or "inexhaustible," and 4 refer to partial recovery or replenishment after reduction. In 45 out of 59 papers, therefore, approximately three-fourths, the process of exhaustion is recorded, at times already

complete. Of these, 26 state the cause as pearl-hunting, mainly or wholly, and 10 refer to other agencies, one or two each to high or low water, deposits of sand or mud, ice, boats, hogs, and rats. Of 7 answers from Wisconsin, where so many pearls of remarkable beauty were found in the early "nineties," 5 report the shells as nearly or entirely exhausted, and 2 refer to rapid reduction, due to ignorant and careless persons taking the small and young shells as well as those more likely to contain pearls.

A Tennessee paper alludes to the same reckless habit, and estimates the shells remaining as about 5 per cent only of the number in former years. The destruction of young shells is also mentioned in Indiana. In New York it is stated that a good pearl-fisher can "clean out" a bed of 500 shells in a day. The Ohio paper speaks of hundreds being opened daily. In Iowa one states that the river will be exhausted in two years. Of those that speak of little change, several remark that not much is known or done in regard to pearls at their localities. Of the probability of recovery, one, Tennessee, says that the beds are cleared out about every two years and renewed in four; one that they exhaust yearly and bed again in one or two years; another that the shells return every year, but in less numbers, and a Texas paper reports that many beds that had been worked out are recovering, through the growth of the young shells that were left unmolested.

### NATURAL AND ARTIFICIAL REPLENISHMENT OF FRESH-WATER MUSSELS.

The inquiry as to whether exhausted beds recover, and in what time, is closely connected with the preceding one. It is unanswered in 22 of the papers, and 7 others report no knowledge or opinion on the subject; 64 replies are given, of which several are indefinite or conjectural. Out of about 60 papers, therefore, or two-thirds of the whole, the following data are taken: 16 report the belief that the beds are replenished from year to year; 4, in one or two years; 3, in two or three years, and 4, in four years; 4 name periods between four and eight years, and 6 between eight and twelve years; 1 gives twenty years, 1 gives twenty-five, and 2 estimate the recovery as requiring a century or more; 3 papers say that many years are necessary; 5 say "a few," or "soon"; 2 report no exhaustion as noticed, and 6 report no recovery; 4 papers are indefinite or uncertain. Two of the papers that give estimated dates for recovery do so with an expression of doubt ("if at all," "if ever") as to whether it really occurs.

The Tennessee paper before referred to says that the shells return each year, but in less numbers. As it is customary, more or less, to leave the young and small shells, the questions are resolved largely into two, viz, how far they have been carefully spared, and how long it takes them to attain their growth. This probably differs in different species, as is intimated in some of the answers, and it may also be influenced by various external conditions. The Tennessee paper estimates the recovery as slow, from the fact—previously brought out very markedly—that the young shells are those that are most exposed to all natural enemies and accidents. The New York paper, which thinks that there is no recovery, states that few young shells are found. A Texas pearler says that young shells are found in two years, but contain no pearls. One (mentioned under the last head) says that many beds are recovering by the growth of the young that were left before. On the other hand, in Indiana, one states that when a bed has been worked out, plenty are found the next season, and an Iowa pearler reports young shells abundant everywhere. One Tennessee answer probably gives a very fair average statement, to the effect that the beds recover somewhat every season, and would perhaps recover entirely in a few years if not molested.

### NATIONAL AND STATE PROTECTION.

The concluding inquiry, as to whether State protection of the beds is desirable or necessary, is answered with more or less definiteness in 73 papers, and, as might be expected on such a subject, with much diversity; 46 of the responses see no need or advantage from protection and 23 favor it. One or two fail to understand the purpose of the question clearly, and some hold that while not necessary now it may be so in the future. Two or three say that it would be difficult or impracticable. Of those that do not favor protection two (Michigan and New York) think it not desirable to preserve the Unios, the latter curiously remarking, "The water would be purer without them." And one Tennessee fisherman seems to hold a similar view, saying that protection is not desirable, though it is necessary to the preservation of the shells. Another Tennessee pearler, failing to appreciate the question involved, opposes protection, "because pearls bring in a great deal of money, and the mussels are of no use." Two or three think that the shells are inexhaustible and in no danger of extinction. Of those that favor the suggestion, an Indiana pearler says it would be well if no shells were taken for five years. The Ohio paper advocates it "if the mussels are to be preserved." A Tennessee paper alludes to the value of the shells for pearl buttons as a reason for protection, and two other Tennessee papers advocate a limitation as to not opening young shells.

The whole question is curiously suggestive of the similar conditions in respect to forestry and lumbering—the apparently inexhaustible natural supply; the reckless prodigality and waste of such resources by man; the rapid diminution and impending extinction, which it would require years of labor to restore; the foresight and remonstrance of the few, and the indifference or opposition of the many, as to any limitation or protection designed to preserve the natural resources; and the ease with which they could be preserved by a few simple and intelligent modes of management, once established and made familiar to the people; and the pressing importance of some such action.

### APPROXIMATE YIELDS OF PEARLS.

Only a few approximate figures can be given. The total production of pearls may be summed up as follows: In the 1856 excitement $50,000, worth to-day at least four times that amount; in the 1868 excitement $50,000 worth; in the 1889 Wisconsin excitement perhaps $300,000 worth; the Tennessee fisheries $100,000; Kentucky $20,000; Texas $20,000; Arkansas produced single pearls in the past year of a total value of $35,000, some selling for over $1,000 apiece, and many for over $100 and $200.

The great importance to a rural population of obtaining ready money easily by pearling can not be overestimated, the pearlers being aided in the payment of taxes, interest, and for such things as only money will buy; and the protection of the pearling interests is, therefore, very desirable, as the industry, if properly regulated, yields a product which can always be sold for cash.

NEW YORK CITY.

# THE RED SNAPPER FISHERIES: THEIR PAST, PRESENT, AND FUTURE.

By ANDREW F. WARREN.

The subject assigned to me is one whose breadth covers the whole of the Gulf of Mexico, and whose history extends from the times of myth, commonly designated "before the war." This history must be based mostly on fishermen's tales, which are of proverbial authority, but whose credibility no disciple of Saint Peter would deny. During the little time I have been able to snatch from other duties I have interviewed such old-timers as still survive, and have compiled this history from their accounts.

Somewhere in the late forties or early fifties some New London fishermen ventured into the Gulf of Mexico in pursuit of snappers. They sailed in small sloops, such as were used in the cod fisheries on the Nantucket shoals for New York market purposes, none being over 15 or 20 tons measurement, and carrying in their wells loads of live fish of not more than 5,000 or 6,000 pounds. The catch was sold at New Orleans at a price commensurate with the dangers of the passage from the home port and with the scale of values that then governed the markets of New Orleans in all lines.

Capt. Leonard Deskin, of New London, seems to have been the pioneer. He suffered shipwreck on one of his outward voyages and never returned to his home. He settled on the Florida coast, near East Pass, Pensacola Bay, where he lived during the war, and died some fifteen years since, leaving a family who still pursue the same industry.

During the later years of the war the fishery was pursued by other vessels, some of Southern build and others from Connecticut. They mostly disposed of their catch in New Orleans, the fish often selling for from $1.50 to $2 per "bunch." The "bunch" was a varying quantity, ranging—as the state of the market might seem to justify—from 16 to 20 pounds, no "bunch" being considered marketable unless it contained at least two fish; so that only purses filled by the depreciated currency of the day could afford the luxury of a baked or boiled snapper.

The rumors of these prices, together with the allurements of our summer seas, induced some fishermen whose apprenticeship had been served on the Georges Banks and amid the whirling tide rips of the Vineyard Shoals, to wet a line on the Snapper Banks. Some adventurous fishermen, mostly from Noank, Conn., were enticed to make winter voyages to the Gulf of Mexico. Having better and more fully equipped smacks than the natives, they did well, and for some years held the monopoly of the trade in Mobile and New Orleans. This trade, however, was a local and mostly retail trade—the difficulties of transportation, not only in time, but in price, together with the high cost of ice, averaging nearly 2 cents per pound, making a shipping trade impossible. About 1872 the first venture in the snapper business at Pensacola was made, the Pensacola Ice Company being forced into the business by the establishment

of ice factories in the interior of Alabama, where they had before done a considerable business in ice, which was cut off by the new competition.

As is the case with most successful industries, the beginnings were small. During the following five or six years the trade was pushed into every market that could be reached by express or freight, without much regard to present profit, but looking to the future trade for compensation. During this time the business was suspended in the summer months, the principal dependence for supply being on contracts with northern smacks, which came every fall from the North and East and returned home at the end of Lent. This proving unsatisfactory, a beginning was made in 1879 of a fleet owned by the dealers, and so under their control. One vessel was bought. From this single vessel the fleet has now grown until it numbers some 35 vessels owned in Pensacola, 4 in Mobile, and 2 in New Orleans, the latter belonging to retail dealers, who use them for the local trade. This fleet is of many sizes, ranging from 20 to 50 tons measurement, and of varying ages, from 50 years to those which were launched this last year. The old ones are of all descriptions, some having been Boston and New York pilot boats, others eastern bankers, and many were built for the New York and Fulton market fisheries. The new ones are of the most modern design and construction, being the product of the best designers, whose plans have been executed in the shipyards of Massachusetts and Maine by some of the best builders of the Eastern States. Very recently one of this design has been launched from a Pensacola shipyard and built of Florida woods, which it is believed will prove the pioneer of a large fleet, and that thus a new industry will grow up on Florida soil.

At first all smacks were provided with wells for the bringing of live fish and ventured only a short distance from port, seldom going east of Cape San Blas and being satisfied with loads of 5,000 to 6,000 pounds weight. In those days fish seemed more plentiful than now. It was not uncommon for a smack to make a trip every week during favorable weather, landing what was considered a good load on every voyage. As the demand increased and the price of ice became lower the taking of ice to sea in connection with the well fishing was begun. It proved so successful that it soon superseded the well fishing, and for some years only two vessels supplied with wells have been in use, even these depending on ice the most of the year, only bringing fish in the wells during the favorable time in the summer. It has been found that better and sounder delivery to the consumer can be made with the use of ice than in any other way. The introduction of ice has broadened the boundaries of the fishing-grounds so that snappers are now caught as far as the region of Tortugas on the one side, in latitude 24, longitude 83, and at the extreme western end of Campeche bank, in latitude 20, longitude 92, some 700 miles from Pensacola. These voyages are usually made without the use of chronometers, dependence being put entirely on the dead-reckoning as furnished by the aid of the patent log and observations for latitude by the sextant.

The skill that has been developed among the skippers is little less than marvelous, they being able to beat back and forth across the whole breadth of the Gulf of Mexico, making their landfalls with precision, and often being spoken both by sailing and steam merchantmen, who correct their observed position by the aid of the illiterate fishermen, to whom the more exact methods of astronomical navigation are unknown. Masters of dead-reckoning, they are also expert seamen and are able to bring their craft, having a freeboard of only a foot or two, through gales and hurricanes that cover the Gulf with the wreckage of merchantmen of a thousand tons.

In July, 1896, one of the most destructive hurricanes that have swept the Gulf of Mexico was encountered by the smack *Clara*, of only 26 tons register, with her decks not over 18 inches above the water. She rode out the gale in perfect safety, although her decks were swept by the seas, washing overboard all movable articles, and staving her boats, but with no damage to hull or rigging, and able to resume her voyage as soon as these trifling losses were made good. The same storm proved the death of many a staunch ship, and for weeks the public was thrilled by stories of disaster and loss of life. So staunch are these vessels and so skillful their handling, that when danger signals are displayed and winds howl we are in the habit of giving thanks that no more of the fleet are in the harbor, considering those at sea much safer than those in port. In fact, the same July gale above mentioned sunk and disabled six fishermen that were in port, and damaged none at sea.

The crews are of as various lineage as the vessels. Some are from Norway and Sweden, some were subjects of the King of Denmark, some were born under the flag of the Kingdom of Greece, and not a few of these hastened home to assist their country in its late war. The sunny skies of Italy shone over the birthplace of many others; while, of course, Yankees and Nova Scotians are present in great numbers.

In the methods of finding and catching the fish, little change has occurred since the inception of the fishery. The fish are found by the continual throwing of a lead line, carrying a baited hook. A man standing on the weather rail, supporting himself by a hold on the main shroud, swings the line, to which is attached a 9-pound lead; he releases it as it swings under and forward, and lets it swing to the bottom, and 40 fathoms depth is reached as the hand of the leadsman comes over the lead, although the vessel may be moving forward 3 or 4 knots per hour. If fish are present and are hungry, they snatch at the hook, and one is brought to the surface. As soon as a bite is announced, a dory, with one man, provided with fishing gear, is at once launched, and if the fish bite well the smack is brought back to the spot and either anchored or permitted to drift broadside across the ground. When she drifts away from the fish, she is again worked to windward, and the same process repeated until the fish cease biting or the fare is completed. This process of sounding is sometimes followed all day without success; and again, the fish are quickly found. Sometimes six men will catch a thousand fish in a few hours, and at other times two or three hundred fish will be the limit of a day's hard sounding and patient fishing. When the snappers are spawning, they often are so abundant around the smack as to color the water, but refuse to take the hook, and in such times the only recourse is to search for other schools.

Once a load is secured no effort is spared to hasten along, and only the most severe of adverse winds will cause the skipper to lay to and await a more favorable chance. The fish after landing are either repacked in vaults and deeply covered with freshly broken ice or are forwarded at once to market. The conditions of marketing differ from those in any other fishing port, so far as is known. All the vessels being the property of the shipping firms, there is no haggling about prices. For some years past there has been a stable and constant price which is allowed the vessel and which remains the same in times of scarcity or abundance. Out of the price of the fare of fish is first deducted the cost of the ice taken on board at the beginning of the voyage. Then the crew receive a fixed percentage of what remains, out of which their provision bill is deducted and the remainder divided according to the rank and skill

of the individual fisherman. This system, or "lay," as it is called, is the result of many years' experience and of some trials of strength between the fishermen and the owners, and has proven the most satisfactory and fair method of dividing the proceeds of the fishing voyage.

The prices being uniform at all times to the shipper, it has been found expedient to establish a scale, varying with the size of the fish and the shape in which they are forwarded, as round, with entrails removed, or with all waste parts cut away. The sparseness of our Southern population, the great distances which separate the sea from the consumer, and the high price of telegraph tolls, have all tended to discourage any effort to vary prices with the supply, and to encourage the maintenance of standard prices, with some concession to larger dealers. That the prices have been fairly fixed, as a result of years of experiment and many bitter wars between the rival Pensacola shippers, needs little confirmation, in view of the fact that only two considerable shippers have survived the strain and stress of unrestricted competition, although a half dozen other firms have entered the field, only to be absorbed by the older houses after an unsuccessful attempt to realize their hopes of profit. The market reached by the existing houses is one that covers most of the country, reaching from Boston, Mass., to Denver, Colo., and from the shores of Texas to the borders of the Great Lakes. In fact, as one dealer aptly remarked, "No man who is willing to buy a red snapper has lacked the opportunity."

The future of the fishery can not be readily foretold. That the cost of production can be reduced seems unlikely. Climatic conditions compel the marketing of the red snapper in a fresh and unfrozen state. It does not take kindly to freezing; its color fades and its flesh, in the dry atmosphere of cold storage, shrivels and wastes. In fact, it has come to be recognized that no fish can be thus preserved except with considerable loss of flavor and of marketable value. It is almost impossible to distribute frozen stock in these latitudes. No market, either in North or South, has been found that will consume such quantities as might be economically transported and stored in a frozen state. The crude and wasteful methods of the retail dealer also work to raise the cost to the consumer, so that it bears little relation to the price the shipper receives, and the retailer's profit is so large that the consumer finds a mess of fish a costly luxury, in which he indulges only at long intervals. Canning has been tried and found wanting. Preservation with salt is unprofitable, owing to the great loss of weight it entails and the high cost of the raw material, which makes profitable sale out of the question.

The dearth of skilled cooks is also an almost insurmountable obstacle in the way of the introduction of our fish into such general use as is enjoyed by the products of the packing-houses of the West. Another difficulty is that the larger red snappers, which cost least by the pound, can not be conveniently used in a single household, being excessive in both cost and quantity. Great effort has been made, with only partial success, to introduce the custom of selling sliced fish.

The supply afforded by the fishing-grounds, while not threatening immediate failure, seems to be comparatively less than twenty years ago. Before 1880 it was common for smacks to make weekly trips, and they were seldom compelled to go far for good fishing; now they go far and consume more time on every trip, although most of this time is employed on the outward passage and in search of productive grounds. On the other hand, the men earn about the same wages, and the market is kept fully

supplied, interruptions by stormy weather excepted. The supply seems to vary from year to year, some seasons finding fish abundant on one ground, and others showing the fish to have moved their feeding-grounds to other portions of the Gulf.

Many matters relating to the red snapper, its life-history, its feeding and breeding grounds, how quickly it reaches maturity, and its duration of life, have never been sufficiently studied, and we shall be indebted to the officials of the Fish Commission when they have time and opportunity to prosecute to a conclusion researches which will require years of intelligent labor. So far they have had no such opportunity; but it is earnestly to be hoped that they may yet be able to take up the subject as carefully and patiently as it deserves.

It will be noted that statistics have borne no part in my remarks. Inquirers for such information may obtain it in the reports of the Fish Commission.

PENSACOLA, FLORIDA.

# SOME BRIEF REMINISCENCES OF THE EARLY DAYS OF FISH-CULTURE IN THE UNITED STATES.

By LIVINGSTON STONE,

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About a third of a century ago a strange story began to be spread abroad in this country that a man in western New York was hatching trout eggs—thousands upon thousands—and that he was rearing the fish and feeding them in ponds, and that there was literally no end to the number of fish he could hatch. The story naturally made a decided sensation throughout the country, but of all the people who heard the story there were very few at first who believed it. The present age of almost daily recurring marvels had hardly begun then, and people were more incredulous and slower to accept apparent miracles than they are now; and then again, the country being in the throes of civil war at the time, it followed that discoveries in peaceful arts did not attract the attention that they would have done in quieter times. But the story about the man who was hatching thousands upon thousands of trout steadily gained ground. Presently the great New York dailies took it up, and soon after it came to be an accepted fact that something very wonderful was certainly being done by this New York trout-hatcher.

In the meantime the man himself, quietly working away in Caledonia, had succeeded in actually proving beyond a doubt that the hatching of trout on an immense scale—not as an experiment, but as a practical industry—was within the easy reach of human skill. It was the first time that this had been accomplished. Amateur and scientific experiments on a small scale had been made by various persons at various times, and the method of hatching fish artificially had been known for a century, but it remained for Seth Green to introduce into America the hatching of fish as a practical and valuable industry, and to him belong the credit and the honor of opening the way to the vast practical work that has since been accomplished in this country in hatching and rearing fish, and to him eminently belongs the title, justly earned, of the "father of American fish-culture."

A year or two after Seth Green had inaugurated American fish-culture at Caledonia, the writer established the Cold Spring trout ponds at Charlestown, New Hampshire, but strange to say, up to this time, although Seth Green's operations in New York had been so fascinating and so promising, no one else in this country had taken up the breeding of trout at which he had been so successful.

The time, however, was now ripe for the spread of trout-culture, and very soon after the establishment of the Cold Spring trout ponds trout breeding places sprang up in all directions. Raising trout suddenly became fashionable and popular. During the first two years of his trout breeding experience the writer received letters from almost every State in the Union, written by persons actually engaged in, or more

or less interested in trout-culture. The interest in trout-breeding became universal, and everything written about it was eagerly read by all who were interested in fish at all. These were the palmy days of trout-breeding in this country. Prices were high. Trout eggs brought $10 per 1,000 and young trout fry $40 per 1,000. Trout large enough for the table brought $1 a pound at the ponds, and the city hotels paid 75 cents a pound for regular weekly consignments. There was a large demand for trout eggs and a fair demand for young fry and for trout for the table. Trout-breeding prospered, and with it all there was a novelty about the work which had not then had time to wear off, and the business of trout-breeding, for it had now become a legitimate business, came to be a pleasant, prosperous, and profitable occupation.

It would be interesting to describe more minutely the rise and decline of private trout-culture in the United States—for, alas! the decline came only too soon—but that would not come within the scope of this paper. Suffice it to say that competition soon brought prices of eggs and fry down too low to make the business profitable generally, and the market price for table trout falling at the same time, many who engaged in the business fell out for want of sufficient pecuniary encouragement, while others who raised trout for the enjoyment of it gave it up because of the many risks and difficulties which stood in the way of success.

It is a fact worth recording, and one that seems very strange in the light of present events, that while so many at first went to raising trout, no one seemed to even think that it was worth while to hatch any other kind of fish; and it is also a fact worth noticing that if artificial fish-culture had been confined to the raising of trout, as it was the first three years of its career in this country, the vast and beneficent work that is being done at present would have been unknown.

It again remained for the bold and adventurous spirit of Seth Green, with his far-reaching vision, to enter the larger and more important field of hatching fish that had a standard commercial value. Everyone knows of his attempts, his failures, and his final success in hatching shad. These efforts of Green, in demonstrating that other and more valuable fish could be hatched as easily as trout, did indeed open up a field for fish-culture so vast and beneficial to mankind that the previous trout-cultural work shrank into insignificance beside it. Thus it was that Seth Green earned a second time his claim to the title of "father of American fish-culture." All the present magnificent work of our State fish commissions and the United States Fish Commission owes its origin to Seth Green's shad-hatchery on the Connecticut in 1867.

In 1868 the writer, in connection with Mr. Joseph Goodfellow, erected a salmon-breeding station on the Miramichi River, in New Brunswick. This was on a large scale and was the first effort at systematic, practical salmon-breeding in America. As illustrating the high prices for fish eggs that prevailed then, I may mention that the writer received over $1,000 for a good-sized water-pail of salmon eggs from the Miramichi in 1869. This station would have been a valuable source of supply for salmon eggs had not public sentiment in Canada been so strong against exporting Canadian salmon eggs to the United States that the enterprise had to be abandoned; but the Canadian government took it up soon afterwards and sold salmon eggs to this country for the enormous price of $45 per 1,000, or nearly $1,000 per gallon.

I must not forget to mention, as among the most important events of the early days of fish-culture in this country, that the State of New Hampshire, with singular foresight, established a fish commission in 1864, the same year that Seth Green began

operations in Caledonia. New Hampshire was soon followed by Massachusetts and other States, and in 1871 the United States Commission of Fish and Fisheries, through the efforts of Prof. Spencer F. Baird, was created by Congress, and the same year, also, the American Fish-Culturists' Association was formed, now the American Fisheries Society. By this time there were also innumerable trout-culturists in the field, and fish-culture in the United States may be said to have passed the days of its infancy and to be fairly on its feet.

In looking back over those early years and contrasting them with the present, when such an immense mass of information is available, one is forcibly struck by the almost universal ignorance on the subject that prevailed at that time. This was true not only of people generally, but of well informed men also, for even scientists who rightly deserved the name, and university graduates and accomplished scholars who prided themselves on the variety of their knowledge, and reading men who kept up with the magazines and newspapers, could tell you nothing of this new art of fish-culture. Yet this was not so very surprising, for books had not then been published in this country on the subject, magazine articles about it had not appeared, cyclopedias did not contain the information, or at most only the merest outlines of it, and unless one happened to come across the not easily-accessible reports of specialists there was no avenue open to the public by which more than a superficial knowledge of the subject could be reached. People generally were so utterly ignorant indeed of the whole subject that almost any story told about fish eggs would pass unchallenged. How different from the present day, when the minute fish life of the very bottom of the oceans is closely and thoroughly studied, and the fish food furnished by the microscopic life of the fresh-water lakes is measured and classified.

To go back in memory to those early days is not only to enter the enchantment that distance brings, but it is also to return to what was a real enchantment then. It seems as if we should never feel again—I know I am expressing the feelings of all the early experimenters in hatching fish—it seems as if we should never feel again, and we probably never shall feel again the thrill of excitement that tingled to our fingers' ends when we first saw the little black speck in the unhatched embryo, which told us that our egg was *alive*. It was one of the dearest sights on earth to us then. And when the first little trout emerged from his shell and wriggled in the water, why were we so excited and elated? Was it because we unconsciously felt that we were sharing with others in a great discovery? Was it because that little fish opened up to us a new world of promise, and because we had a dim vision of the countless multitudes of living creatures that this little embryo was the insignificant forerunner of? I suppose it was something of the sort, and now after those long years have passed and we coldly watch under a microscope, with half-scientific interest, the development of this little black speck, named by scientists the "choroid pigment," but which will always be dear to us as the "eye-spot," we can hardly believe that such a commonplace, matter-of-fact affair could ever have stirred our feelings and our imagination as it did once, when the sight and the sensation were both new, and the world of promise before us was untried and unknown.

Recalling those early years, two figures stand out in memory more prominently than all others. One is the figure of a strong-featured, broad-browed man, of a rugged frame and a rugged countenance. He had the bearing and the look of a man who thought no struggle too severe for him and no foe too formidable. He looks the strong man that he is. He is of the Zachary Taylor "rough-and-ready" type, but withal he

has a hearty and genial manner, and a frank and honest nature looks out of eyes that show that no shallow mind lies behind them. Every fish-culturist knows whom I mean. I had previously visited Seth Green at his home in Caledonia, but it was not till I met and assisted him at Holyoke, in 1867, that his strong personality impressed itself on me. He was there conducting his first experiments in hatching shad. He was entirely alone when I visited him, and his first attempts at hatching shad had just ended in signal failure. The peculiar character of the eggs and the peculiar treatment required for them had baffled for a time even his keen-sighted genius, and he had in despair almost decided to give it up and return home. The fishermen he had hired to help him were laughing at him for what they called his "foolishness." But, although alone and depressed in spirits, and with no one to offer a word of encouragement, Seth Green kept on and, with dogged persistence and determination, fought and overcame one difficulty after another, as they met him, until at last he was rewarded, as the world knows, with overwhelming success. Perhaps I may be allowed to add that a warm friendship sprang up about this time between Seth Green and the writer, which continued to the day of the former's death.

It was a pleasant thing to see the change in Green's spirits that came with his first success in hatching shad. It seemed a little thing—nothing but some little delicate living embryos appearing in the frail eggs that he was working over. Little it was, but it was the herald of almost illimitable possibilities, which perhaps the man himself did not fully realize. But however that may be, it restored his spirits and made him almost instantly a changed man.

The writer once asked Gen. Phil. Sheridan what was the most thrilling moment of his career during the war of the rebellion. General Sheridan answered laconically, "When the tide turned at the battle of Winchester." I think that perhaps Seth Green's feelings at Holyoke, when his first shad eggs showed signs of life, might have been somewhat similar. He was attempting what no one else had ever thought of accomplishing and vast results were depending on his efforts. The eyes of all the fish-cultural world were on him. Thus far he had failed. He was for the time being defeated. Then the tide suddenly turned, and almost literally in a moment the whole thing was changed and he was victorious in a great battle, the far-reaching results of which will doubtless survive even the great nation that Sheridan fought for.

Green's strong traits of character were not the only things about him that called attention to the man, for united with these were a sound judgment and many rare gifts of genius. He had the happy faculty of seeing and fixing his mind on the one essential point to be attained, to the exclusion of everything else, and he had the fine discrimination which enables one to retain all the means necessary to accomplish his object and to eliminate all others. This enabled him to reduce his inventions and methods to the utmost simplicity without impairing their efficiency—the sure sign of genius. Green's famous shad-hatching box, than which nothing more simple and effective has ever been invented for the hatching of fish, is a good illustration of this genius, and his world-renowned skill at fly-casting, rifle-shooting, and fish-catching are only further illustrations of the same thing. I regret that time and space forbid my giving anything more than this very imperfect sketch of this remarkable man, but I must hasten on.

The other figure which stands out prominently in my memory, as I recall the early days of American fish-culture, is that of one who has been called a plain man. He was a plain man, indeed, but one who was made after nature's largest pattern of

men. He was large in mental caliber and large in physical frame; large in his broad sympathies and in his wide scope of vision; large in his comprehensive grasp of great aims and large in his capacity for great undertakings; large in everything, but small in nothing. You at once, I know, recognize Spencer F. Baird, the first United States Commissioner of Fish and Fisheries.

The mere mention of his name strikes a chord of dear memories in the hearts of all who knew him. No man of our time has left a purer memory, a more stainless name, or a more animating and enduring influence over his special field of labor than Professor Baird. He was loved by those who knew him when he was living. He is revered by those who have survived him. He lived in a higher plane of thought and life and breathed a purer atmosphere than most men. Quiet and unassuming, with a nature as gentle as a child's, his natural superiority never failed to show itself when he was with other men, not even among the distinguished men who gather in the winter at the nation's capital. Yet he was thoughtful and considerate of his subordinates and always ready to give its meed of praise to any work well done by his humblest employee.

Professor Baird had the enviable gift of not only endearing to him all who came in contact with him, but of inspiring them with his own enthusiasm and energy. This made Congressmen vote all the appropriations that he asked for, for it was a common saying at Washington that Congress always gave him everything that he wanted. Like a good general, he had the personal welfare of his men at heart while he was Fish Commissioner, and they in turn wanted to do everything in their power for him, which, doubtless, was one of the secrets of his great success. It is a fact that his employees in the Fish Commission would voluntarily work a great deal harder for him than they would for themselves. It was the inspiration of this patient, disinterested, tireless, kind-hearted, and lovable man that made them work so well and also made that work a pleasure.

It is unnecessary to say that Professor Baird possessed extraordinary mental endowments, but I may perhaps mention one or two, as they are so rare. He had a quickness of apprehension that sometimes seemed almost supernatural. For instance, he would glance down along a printed page and comprehend in a moment what would take others several minutes to read. He had a marvelous memory, not only retentive of everything intrusted to it, but quick to call up anything that was wanted *when* it was wanted, a quality that most of us know well how to appreciate. His mind was also of the clearest type. No complications ever seemed to confuse him; he never became involved during his conversations, no matter what were the intricacies of his subject. His mind, like his placid temper, never seemed to be ruffled or disturbed. Extraordinary as his mental faculties were, he had evidently added to their efficiency by severe discipline, for he possessed that infallible mark of a well-trained mind, of having all his great and diversified stores of knowledge classified and grouped together in his brain according to subjects, so that he could call up his whole knowledge of any subject at a moment's notice. Another remarkable thing about his mental composition was that with a thoroughly scientific cast of mind were united qualities of the most practical character. He was a scientific man by nature. He loved science and scientific studies, but at the same time no man had a sounder judgment or a clearer head in the management of practical affairs. It is very rare to see scientific and practical qualities of mind united in such an eminent degree as they were in him.

Professor Baird was gifted with still another unusual mental endowment, which reminds one strongly of one of the traits of the first Napoleon. With that comprehensiveness of mind which takes in the broad features and large, general outlines of a great enterprise, he combined, as Napoleon did, a capacity for close and thorough attention to all the details of a subject, down to the minutest items necessary to success. This combination, as we all know, is a rare one. As an illustration of his wonderfully retentive memory and easy grasp of details, as well as his remarkable gift for a rapid dispatch of practical work, I may mention a little incident that occurred at Calais, Me., where I visited him in 1872, and which has fastened itself on my mind ever since. He had received twenty-seven letters by the mail of the day before—I remember the exact number that he told me he had received—and the next forenoon, after breakfast, he called in his stenographer for the purpose of answering them. As I, very naturally, rose to leave the room, he kindly invited me to remain and be seated, and I shall never forget the impression which the subsequent answering of those letters left on me. Assuming his customary attitude, when on his feet, of holding his hands behind him, one wrist grasped by the other hand, he leisurely walked up and down the room, dictating to the stenographer the answers, one after another, to all his letters. He did not, to my knowledge, once refer to one of the letters he had received, either to ascertain its contents or to get the address of the writer, but proceeded from one letter to another until all were finished. And, further, during this time he never showed the slightest hesitation, nor did his countenance betray any signs of mental effort or confusion. It was a remarkable feat of memory and of the methodical dispatch of business details which I can not forbear to mention.

In our subsequent acquaintance and correspondence, which was very extended, both personal and official, his letters were always marked by great kindness of heart and thoughtful consideration, which, it is needless to say, warmly endeared him to the writer. It is a great pleasure to me now to think that the United States Fish Commission station that I located and built up three successive times, on the McCloud River, in California, has kept the name which I gave many years ago to the little post-office on the river, and, as Baird station, contributes its mite to perpetuating the name of the great first United States Commissioner of Fish and Fisheries.

I said that there were two figures which early associations with fish-culture called up very forcibly to my mind. There is also a third. It is of a man who never has been in America, yet whose love for America, whose admiration for American fish-culture, and whose influence on fish-cultural work in America have been very marked. I mean the Count von Behr. With a thorough love of fish-culture and devoted to it, with an unusually enthusiastic nature which specially fitted him for inspiring others with his own love for it, Herr von Behr was to Germany in this field of labor what Professor Baird was to America. He was for many years the president of the Deutsche Fischerei Verein, the national fish-cultural organization of Germany, and during his whole connection with it he was the life of the association. He was also the animating spirit of the great International Fisheries Exposition in Berlin, which will forever remain memorable in the annals of the world's fish-cultural history. Though of a wholly different type from Professor Baird, he nevertheless possessed qualities which caused his influence to overshadow all other fish-culturists in his own country, as Professor Baird's did in this country, and made him *facile princeps* in conducting the cause of fish-cultural development in Germany.

It was the writer's privilege to carry on a delightful correspondence with Herr von Behr for several years. Dropping all official forms and, indeed, all formality whatever, his letters were earnest, confidential, and full of enthusiasm. They expressed the same love and admiration for Professor Baird that Americans felt for him at home, and never lacked in expressions of his great admiration of American fish-culture. They also record his sad domestic bereavements, and told how, after the loss of his three sons, he had resolved to devote the remainder of his life to the cause of fish-culture in Germany. I am aware that much criticism has been expressed because Von Behr's name has been given by Americans to a European trout since its introduction into this country; but whatever may be said of the judiciousness of the act, no one can deny that it was a fitting compliment to a man who richly deserved the honor, nor can anyone deny that it reflects credit on the kindly feeling which sought in this way to recognize America's indebtedness to Von Behr, and to perpetuate in America the name of the distinguished German fish-culturist.

The Count von Behr was a generous, warm-hearted, lovable man, and his contributions in labor and in influence to the cause of fish-culture can never be measured. He was one of those who formed the great triumvirate of the early history of practical fish-culture—*Green, Baird, von Behr.* Hopeful as we are of the future fish-cultural work of the world, we nevertheless confess to feeling a presentiment that "we ne'er shall look upon their like again."

I regret that this disjointed and imperfect sketch must suffice for the present for a subject that deserves better treatment. I would like to speak of Frank Buckland, of England, who did so much to encourage fish-culture in Great Britain; of Professor Milner, the zealous and conscientious colleague of the writer; of Robert B. Roosevelt, who edited the first newspaper column in this country exclusively devoted to fish-culture; of Theodore Lyman, of Massachusetts, the leading spirit in the first fish-cultural movement in New England; of Judge Bellows, of New Hampshire, who took the first steps in this country toward the public recognition of fish-culture; of Governor Horatio Seymour, of New York, who gave his powerful influence to its support, early in the seventies, and of many others who contributed more or less prominently to its early development. But both time and space preclude the possibility of this, and I can only congratulate my brother fish-culturists that there are so many devoted workers in the cause still living to fill the places left vacant by their faithful predecessors who have gone to their reward.

# THE RELATIONS BETWEEN STATE FISH COMMISSIONS AND COMMERCIAL FISHERMEN.

By W. E. MEEHAN.

It must be obvious to every person engaged or interested in the work of fish-culture that the relations between the mass of the commercial fishermen and the State fish commissions are not as cordial as they should be. In fact, to put it plainly, in many places these relations are strained to such a point as to practically amount to open antagonism on the part of the former against the latter. It is also undeniable that there is a large class of citizens—some of whom can not be regarded in many respects as unprogressive—openly opposed or indifferent to the work of the fish commissions, and some even go the length of actively opposing the enactment and enforcement of stringent laws for the protection of fish. This antagonism is so potent as often to exercise a sinister influence on legislation.

In many States it is difficult and often impossible to secure the passage of efficient fish-protective laws, while measures to legalize the employment of the most destructive devices for taking fish find numerous supporters and comparatively easy passage. Few States grant liberal appropriations for fish-cultural work, and I know of none that grant as much as could be profitably expended. In Pennsylvania the last legislature adjourned without making any appropriation at all; and in Michigan, where fish-cultural work is carried on with exceptional effectiveness, if I have been correctly informed, the last legislature cut the usual appropriation in half. These are not encouraging signs for the future of fish-cultural work, and it behooves those interested to find out the cause of the trouble and remedy it if they can.

It has been less than thirty years since the establishment of fish commissions, but in that time they have returned to the people many hundredfold the moneys which they have expended. They have in countless instances prevented the extinction of valuable food-fishes and have successfully introduced others equally valuable; they have in many cases largely increased the supply and made fishing waters profitable that were for years before financially unprofitable. But these things seem to weigh very little with the mass of the commercial fishermen and those who demand the right to catch fish when, how, and where they please.

By the united action of New York, New Jersey, and Pennsylvania, all destructive devices were torn from the Delaware River at an expense of some $5,000, and through heavy stocking on the part of the United States and the Pennsylvania fish commissions, the shad industry of that stream was brought from a value of between $60,000 and $80,000 to nearly $500,000 at the nets every year—a consumers' value of more than $1,500,000. This magnificent result is well known throughout Pennsylvania; yet it did not prevent the commercial and semi-commercial fishermen in other parts of the

State from introducing and carrying through both branches of the legislature a section of an act which permitted the use of fish-baskets, and which act was only prevented from becoming a law through Governor Hastings interposing a veto. The situation in Pennsylvania is practically the situation in most of the States where the fresh-water fisheries are or should be large.

The path of fish commissions is not strewn with roses. On the contrary, it is beset with difficulties calculated to discourage the most ardent. An investigation of the causes which produce the strained relations between the commissions and the fishing interests reveals so many that to remove them all seems almost a hopeless task; nor is the apparent hopelessness of the task materially lessened by the conviction that many of the complaints against the methods of the commissions are trivial, and that in other cases the complainants are utterly in the wrong. I believe there would be a better prospect for an earlier settlement of the troubles were it not for the undoubted fact that the relations between the sportsman angler, and the commercial fisherman are anything but harmonious. Each seems to regard his interests as paramount to those of the others. Little consideration is shown by each for the other. One charges the other with trying to ruin his business or pastime. In the controversy the commissions suffer; and as long as the bickering continues, the work of fish-culture must be hampered. This lack of harmony is greatly to be deplored, because both the commercial and sporting fishermen confer huge benefits on the States. The financial returns of the commercial fishermen are more readily reckoned than those of the sportsmen, because more direct; but should those of the latter be fairly gathered and tabulated, the total would be startling. There are many counties in a number of the States where trout, bass, or other game fishing is considered good, in which the people, outside the towns and large villages thereof, owe the chief means of their livelihood to the visiting sportsmen.

Putting aside the question as to which brings in the greatest financial returns in the course of the year, it may be stated with positiveness that both interests are essential to the good of the State. It is the duty of fish commissions to guard and further both, and I believe that as a rule they perform it to the best of their ability; unfortunately, however, in the performance of this duty to its fullest extent, as they see it, they are often apt to give apparent cause for grievance on the part of commercial fishermen that the sporting interests are guarded at the expense of theirs. For example, in Pennsylvania the commercial fishermen complain that they are practically debarred from the unrestricted catching of certain of the commoner food-fishes, like the eel and sucker, through the severity of the laws formulated at the instance of and enforced by the fish commission. In effect the laws in question forbid, under heavy penalty, the use of any device whatever for the catching of fish, other than rod, hook, and line, in any of the waters of the State except Lake Erie and the Susquehanna and Delaware rivers. In Lake Erie pound and other nets may be used under certain restrictions; and in the two streams named, seine and gill nets of a prescribed mesh may be used during certain months, provided the latter be not fastened in any manner; in other words, they must float with the tide or current. By this it will be seen that fyke, dip, cast, and, in fact, all other forms of nets, including fish-baskets, are prohibited.

There is not the slightest doubt that a strict enforcement of this law, or the faithful compliance with it on the part of the fishermen, together with the heavy and

persistent artificial hatching and planting of fish, would result beneficially to the fishing interests, both sporting and commercial. The results in the Delaware River prove this beyond the possibility of dispute. This being the case, other things being equal, there is no question of the propriety of forbidding the use of any device which will in any manner tend to depopulate the streams. Fish like the shad, herring, and striped bass are of far greater consequence than eels and suckers. Unfortunately, "other things" are not equal. The element that exclaims against the severity of the laws and demands the right to employ devices to catch eels, suckers, and commoner food-fishes, is strong enough in Pennsylvania and in other States to check the efficiency of the fish commissions and in some instances to shape vicious legislation.

After some years' thought on the subject and as a result of investigating the demands of the commercial fishing interests and of personal struggles to secure the passage through the Pennsylvania legislatures of efficient fish-protective laws or the defeat of bad ones, I have about come to the conclusion that true fish protective work, as advocated and attempted to be carried on by fish commissions, is in advance of the times. If I am correct in this assumption, it then becomes not out of place to consider whether or not it is expedient to yield something to the present demands of the commercial fishermen, even though by so doing their interests are not truly served, and wait for time and education to bring about a better state of affairs. I am inclined to believe that the commissions can accomplish more in the long run if they adopt this course. The pulling of the commercial fishermen one way and the fish commissions another is not calculated to advance the cause of fish-culture.

I think Professor Baird advanced the idea that it is better to so increase the supply of fishes by artificial propagation that protective laws should not be necessary; that it is cheaper to make fish so abundant that the fisheries need not be restricted than to spend large sums of money in preventing people from fishing. Theoretically, this is an ideal proposition, but, unfortunately, under existing conditions it does not and can not work. If State legislatures would appropriate money enough to carry on the work of artificial fish propagation to an extent eight or ten times what is now done the experiment might be worth trying, but anyone who has attempted to get a moderate appropriation through the legislature knows how hopeless such an effort is. The tendency of those who control legislatures is rather to interject politics into the commission than to assist them to advance the cause of fish-culture. Under these circumstances it is necessary to have fish protective laws; but to what extent in order to produce the best present results for fish-culture?

It may be considered heresy to surrender any part of a principle for the sake of expediency, but when fighting for a great object it seems to me that the greatest advances are made by adopting a give-and-take policy, to gain and retain the regard and respect of the other side, and to take what can be got from time to time with a feeling that it is a step toward the final objective point. As matters now are, I can not see that the fish commissions have advanced much, if any, in popular estimation in the last four or five years. On the contrary, it appears, in some States at least, that they have had as much as they could do to hold their own. In Pennsylvania, as I have already noted, the legislature adjourned without making any appropriation for fish-cultural work during the next two years; and out of the popular subscriptions, amounting to some $15,000, which have been made to supply this neglect or oversight, only $1,000 came from the commercial fishery interests, and that from Lake Erie. In

Michigan the annual appropriation was cut down one-half, and in West Virginia the office of fish commissioner was abolished entirely. Under such conditions it seems not only the part of wisdom but of necessity to make some concessions.

I believe the time will come when commercial fishermen generally will recognize the injury to their interests by the use of overdestructive devices, whether they be fish-baskets, pound nets, salmon wheels, or their allies, and that the fish commissions are working for and not against them; but such conditions do not exist now, and it is the present aspect which must be faced.

I believe that certain devices prohibited by law in many States, such as set or out lines, fyke nets, dip nets, and even set nets, while they ought not to be used, would not, under certain restrictions, materially injure the work of fish-culture. I believe that fish-baskets are the most destructive device in existence for taking fish, with the possible exception of explosives. Under no circumstances should they be permitted in streams into which shad come to spawn, and nowhere else ought they to be allowed without being guarded by severe restrictions or without a license being first paid therefor.

But, above all things, it is important that the commissions and the commercial fishermen come to a better understanding; that they work more in harmony for the advancement of fish-culture. It is also essential that the sporting element and the commercial fishermen cease their jealousies and suspicions of one another and, each recognizing that the other forms an important link in the State's welfare, join hands in hearty support of State fish commissions and their work.

PHILADELPHIA, PENNSYLVANIA.

# POSSIBILITIES FOR AN INCREASED DEVELOPMENT OF FLORIDA'S FISHERY RESOURCES.

By JOHN N. COBB,
*Statistical Field Agent, United States Fish Commission.*

During the course of my various investigations of the fisheries of Florida the fact was brought very forcibly to my mind at different times that there were numerous opportunities for an enlargement of her trade in fishery products. Nearly all of the fishery products of Florida are either sold fresh or in a salted condition, very little canning being done. During certain seasons the markets are crowded with fish in the fresh state, and fishermen are compelled to suspend fishing until this glut is over. This means a heavy loss at frequent intervals. If there were smoking-houses and canning-factories convenient, there would always be a steady demand for certain fishes, which would largely prevent such gluts in the fresh-fish markets.

The State has a great variety of animal life along her immense coast line, but lack of energy and capital with which to prepare and market what are commonly known as "secondary products" prevents her occupying a much higher place among the States as regards the fisheries. Even in marketing fresh fishery products she does not utilize all her resources. I will first take up the question of fishery products sold fresh, and show where I think an expansion could be had.

## FISHERY PRODUCTS IN THE FRESH STATE.

*Catfish.*—One of the commonest varieties of fish in the waters of Florida is the catfish. At nearly all seasons of the year they are found in the rivers in incredible numbers. The people of Florida have always considered them unfit to eat, but this opinion is not universal throughout the country, the people in the States bordering on the Mississippi, Missouri, and tributary streams being especially fond of catfish. St. Louis is a very good market for this fish. At present a small quantity is shipped from Apalachicola, and one firm at Jacksonville does a considerable business, but there is room for an immense development of the fishery. It should be understood that reference is made to the river catfish and not to the sea catfish; the latter does not appear to be popular anywhere.

*Sturgeon.*—This valuable fish is very common in the rivers tributary to the Gulf of Mexico. Spasmodic attempts have been made at times to carry on a sturgeon fishery, but they soon died out. During 1896 a party fished on the Suwanee River with gill nets and secured a number. There is an excellent chance for carrying on this fishery in most of the rivers north of Tampa Bay.

*Crawfish or spiny lobster.*—This crustacean is very common in Florida, especially around Key West. It has an excellent flavor and would doubtless meet with a ready sale if it were shipped North in a fresh state. It would be a good substitute for the lobster, which is growing scarce and expensive.

*Clams.*—The hard clam, or quahog, is very common on the Florida coast, particularly on the lower west coast. A few are gathered and sold locally at Key West and Tampa. These are very large and of an excellent flavor, and by a little effort on the part of the dealers a more extended market for them could be found in the inland towns among people who could not afford to buy oysters.

*Frogs.*—One of the most delicate and popular of fishery products is obtained from the frog. During the winter, especially, frogs' legs command a very high price in the northern markets. There are plenty of frogs in Florida waters and the fishery could be profitably prosecuted in the winter. The expense for apparatus would be slight, either a small rifle or light spear being required.

### FISHERY PRODUCTS IN THE SMOKED STATE.

One of the best and cheapest methods of preparing fishery products is by smoking. This can be done with very cheap appliances, which are within the reach of almost any fisherman. At certain seasons there is a glut in the fresh-fish markets, and unless the catch can be prepared in some such manner fishing must either stop or considerable loss must ensue. There are a number of Florida fishes which can be utilized in this way, and among them may be mentioned the following:

*Alewife.*—Large quantities of these fish, locally known as "herring," enter the St. John's River for the purpose of spawning, about the same time as the shad, but, owing to the poor prices realized, very few are caught. If properly smoked they would make a good cheap food for the poorer classes of the inland towns of the South.

*Mullet.*—The above remarks apply to this common fish. Some smoking is at present done by individuals for their own use. A little capital invested in the business would soon develop a good trade.

*Sturgeon.*—There is an excellent demand in numerous markets for sturgeon in the smoked state, and it would be profitable to smoke what could not be sold fresh.

*Crevalle.*—These fish, which are rather insipid when in the fresh state, are said to be excellent when smoked. As they are very common it would undoubtedly add to the fisherman's income if he prepared his catch in this way.

### FISHERY PRODUCTS IN THE CANNED STATE.

With the exception of the canning of oysters and a small business in the preparation of turtle soup, no fishery products are prepared in this manner. A number, however, could be profitably utilized, and I would mention the following:

*Fishes.*—The fishes locally known as "sardine," "pilchard," "herring," and "anchovy" exist in very large quantities along the Florida coast, especially at Key West, Biscayne Bay, and the lower west coast. The only use made of these fish at present is for bait in the Key West line fishery. A number of firms in Maine have developed a large business in the canning of the small herring as "sardines," and it is very probable that the fish mentioned above could be prepared by the same process as the Maine packers use, and would prove an acceptable food product. If a sample lot of these were prepared and placed upon the general market the question of their adaptability would soon be settled.

*Crawfish.*—These can be easily prepared by the method used in canning lobsters. They would make an excellent substitute for the popular canned lobster, and there ought to be very little difficulty in building up a market for canned crawfish, especially in the Southern States, where its excellence is well known.

*Shrimp.*—Shrimp are very common in Florida, but very little attention is given to their sale in other than the practically fresh state, and in many coast towns the fishermen throw them back into the water when found in the nets. A shrimp-canning factory at some good locality would undoubtedly be a paying investment if in the hands of experienced persons.

*Green turtle.*—An excellent opportunity exists for the development of the business of preparing green-turtle soup. One person is now engaged in this business at Key West, but he is so overrun with orders that he has restricted himself entirely to supplying the foreign demand. There is at present a considerable domestic demand, and this could easily be enlarged should the business be taken up by experienced and energetic persons. There is no apparent sign of a decrease in the number of green turtles landed at Key West, and if the factory were located there a supply could easily be secured during the season. A factory, possibly at or near Miami, might be successful if the turtle fishermen, who work on the east coast and sell their catch at Key West, could be induced to land their fare at the factory. There is hardly a doubt of this, as it would save them the long journey to Key West. Turtle meat can be canned in the same way as other food products, and this would be a good method of disposing of green turtles too large for shipment to northern markets in the shell.

*Clams.*—In the North clams are frequently put up in cans the same as oysters, and this would be an excellent method of utilizing those that could not be sold fresh.

## MISCELLANEOUS PRODUCTS.

*Porpoise oil and leather.*—The securing of oil and leather from this mammal is a profitable business in several sections of this country. As porpoises are very common along the Florida coast a remunerative fishery might be established.

*Crab.*—The horseshoe or king crab is said to be very common in Tampa Bay. While not an edible product it makes a fine fertilizer. Thousands of pounds of these crabs are used each year by the farmers along the Delaware Bay and other waters. As fertilizers are especially valuable in Florida, the utilization of this crustacean for the purpose mentioned is suggested.

*Seaweed.*—This common substance makes excellent and cheap manure, and owing to the very large extent of coast possessed by the State is easily within the reach of all. When buried in the earth around the roots of plants and trees it acts very rapidly, softening and decomposing in the soil so quickly that the effect is confined altogether to the special crop to which it is applied.

*Shells.*—Numerous and beautiful shells are constantly thrown up on the beaches in Florida by the storms, and if these were more generally gathered and shipped to northern points they would find a ready sale, and thus add a considerable amount to the yearly income of the fisherman without much inconvenience or trouble to himself, as the season when they are generally found is the time when he is compelled to remain at home on account of the storms. New York City and the various seaside summer resorts of the North are the best markets for these shells.

In conclusion I would state that, owing to the necessarily restricted length of this paper, I have not taken up the details of the processes necessary in preparing the various fishery products mentioned, but any information in the possession of the United States Commission of Fish and Fisheries will be placed at the disposal of anyone who may be moved to proceed on the lines suggested.

WASHINGTON, D. C.

# THE UTILITY AND METHODS OF MACKEREL PROPAGATION.

By J. PERCY MOORE.

The esteem in which the mackerel is commonly held as a food-fish and the great importance of its pursuit and capture to a large part of the population of certain sections of New England have naturally caused the welfare of the fishery to be jealously guarded. During the past decade the frequent failure of a season's fishing to earn profits has given rise to a fear that the supply is in danger of speedy exhaustion. It was this supposed danger which several years ago led those who have labored in the interests of improved fisheries to experiment with the artificial propagation of the species. It was hoped that the method which had repeopled so many depleted streams and lakes, which not only saved from extinction but extended the shad fisheries, and which is no doubt destined for still greater triumphs in the future, would be capable of rejuvenating some of our decrepit sea fisheries. Though the evidence is by no means unequivocal, these hopes appear to have had a certain warrant in the cases of two sea fishes, for which suitable apparatus and methods have been devised. It is the purpose of the present sketch to point out what appear to be the possibilities and limitations of the method when applied to the mackerel.

The subject may be stated as two principal problems, viz: (1) Is the alleged scarcity of the mackerel a sufficient reason for believing that the supply is becoming exhausted? (2) If so, can the supply be increased and maintained by recourse to artificial propagation?

A glance at the statistics covering the last twenty years may seem to confirm the gravest fears, for from 350,000 barrels in 1880 and 395,000 barrels in 1881 the catch inspected in Massachusetts fell to 75,000 barrels in 1886 and 18,000 barrels in 1891, since which year there has been some slight increase. Fortunately statistics of the catch covering a long period are available for several of the New England States. The late Dr. Goode has presented, in his "History of the mackerel," a curve showing the number of barrels of salt mackerel inspected in Massachusetts annually from 1804 to 1881, and this exhibit has been extended in the annual reports of the Boston Fish Bureau. The frequent and great changes in the course of the curve, corresponding to variations in the number of barrels, are very striking. But a remarkable regularity in the periodicity of the more important fluctuations is apparent. Thus, great catches were made at intervals of about twenty years, in 1831, 1851, about 1870, and in 1881; the smallest catches alternate with these, namely, in 1814, 1840, 1859, 1877, and 1891. Smaller variations of shorter and less regular duration occur between the larger.

By eliminating these minor irregularities, the great movements and the general tendency of the fishery become more evident. This elimination is accomplished by averaging the annual figures for overlapping periods of ten successive years, beginning with each year from 1820 to 1882. The curve plotted from these results is much more uniform than that exhibiting the annual inspection; it rises and falls regularly and gradually at long intervals above and below a line representing the mean annual

inspection of about 230,000 barrels. It also shows that the fishery has not, on the whole, diminished in productiveness. We are therefore justified in assuming, though the hope may prove delusive, that the present period of scarcity will, like all similar ones in the past, be succeeded by a time of plenty. The conclusion follows that the evidence does not point to any necessary or immediate danger of the commercial extinction of the mackerel.

This conclusion may be questioned, on the ground that the catch has held its own only through the increased efficacy of the methods employed. A careful study of the results which have followed some of the more important innovations does not lead to the acceptance of this objection. Many competent authorities have expressed the opinion, which is supported by an array of convincing evidence, that man can exert but little direct influence upon the numbers of those species of fishes which inhabit the open sea. Professor Baird, in writing of the bluefish, shows conclusively that the numbers of this fish have increased and decreased quite independently of the methods adopted by man for its capture, and that man exerts an indirect influence upon its movements in but one respect, namely, by decreasing, through excessive fishing, the available food supply which it derives from the shore fishes. The mackerel, owing to the character of its food, consisting of sand-eels, small crustacea, and other forms not subject to man's direct influence, would seem to be even more independent of the methods of the fisheries than is the bluefish.

It may also be supposed that the greater or less quantities of fish annually captured have been determined by the energy with which the mackerel industry has been pushed. That some of the smaller fluctuations have been due to this cause seems evident, from the fact that during certain years, when the average fares have remained about the same, the catch has been proportional to the number of vessels employed. It is, however, also evident, from the statistics bearing upon this point, that the number and tonnage of vessels employed bear no constant relation to the quantity of fish captured. On the contrary, a very successful year has always stimulated greater interest, and has led to the employment, for several years thereafter, of an increasing number of vessels, while a year of marked failure has diverted vessels and men to other employments. This fact tends to overcome and obscure the evidence which the statistics convey of great and sudden movements in the body of mackerel.

The problem is, however, only shifted. We may feel satisfied that there are no indications of the speedy exhaustion or material reduction of the mackerel supply; but the fact remains that there have been periods, sometimes extending over a number of years, during which the fishery has not paid the cost of operation. It becomes, therefore, extremely important that the cause or causes of these fluctuations should be determined, in order to obtain, if possible, a constant and uniform supply of the fish. It is manifestly just as important to the fishing as to the manufacturing interests that economical regulation of supply and demand should be accomplished. The great evil of the present state of affairs is uncertainty. Capital and labor are attracted or repelled by the appearance of conditions which can not at present be calculated upon beforehand, with a consequent loss in the long run to the fishermen and an increased price to be paid by the consumer.

When the effective causes are fully known the remedy will be indicated; and should it prove to be one impossible of application, it may at least be possible to foretell the prospects of a season and thereby save those interested much disappointment and loss. Many suggestions have been made to account for the fact. Of these we shall consider but four of the most important.

I. It has been contended from time to time, during periods of scarcity, that overfishing or the employment of particular apparatus or methods was to blame. That this theory was advocated even as early as colonial times is evidenced by legislation affecting the methods of taking mackerel which we find recorded in the colonial laws of Massachusetts. With each succeeding period of wane this theory is revived, but its advocates become silent with the advent of prosperity, when the very methods complained of are plied with renewed vigor, or perhaps replaced by more effective methods. The fact that there has been no continuous diminution in the quantity of mackerel taken during the last eighty years, together with the fact of the regular alternation of large and small catches having no casual connection with the employment of new methods, seems to sufficiently dispose of this theory as the sole or even an important explanation. We may quote the weighty opinion of Dr. Goode. He says of the mackerel:

> It seems quite evident that the periods of their scarcity and abundance have alternated with each other without reference to overfishing or any other causes that we are prepared to understand.

The area within which the mackerel is subject to man's influence is but a small part of the vast expanse over which it roams, and the time but little more than half of the year. To one who appreciates the magnitude of the struggle for existence which rages in the ocean, the constant dangers and many natural enemies which beset the mackerel at all times and during every period of its life, the numbers which fall to man must seem but the merest trifle compared to the multitudes which are destroyed by other causes. We may arrive at a reasonable estimate of how insignificant human influence sometimes is by an examination into the history of man's conflicts with the rabbits in Australia, the mongoose in Jamaica, the sparrow in our own country, the locusts and other injurious insects everywhere, etc. On the other hand, there are the cases of the bison, the fur-seal, the great auk, and many other birds and mammals, as well as fresh-water and shore fishes, to bid us be cautious; and we may yet learn that the small numbers (relatively to those which naturally succumb) of mackerel taken by man may turn the balance in the direction of that fish's numerical decline.

II. Infectious diseases may decimate the ranks of the mackerel hosts periodically. This is a possible explanation for which there is absolutely no evidence. Fresh-water and anadromous fishes have been known to be thus destroyed in vast numbers by fungous and other diseases, and a great fatality among the bluefish in the beginning of the century may have had a similar cause; but the subject is an untilled field with regard to sea fishes. The mackerel is almost invariably affected by large numbers of parasites, but these appear to produce no ill effects. No bacterial or other diseases are known. That slight changes in the physical conditions of the sea may destroy life on a stupendous scale is evident from such observed cases as that of the tilefish. If such destruction of the mackerel has taken place the fact has escaped notice.

III. A third and perhaps more worthy suggestion would lead us to seek the solution of the mystery in the effect of environmental influences on the fertility of the species, the relative abundance during one season being the result of greater or less fertility in previous seasons. Or, the actual fertility of the parent fish remaining the same, the physical and other conditions may be such as to destroy the eggs and young in greater or less numbers, resulting in subsequent times of scarcity or plenty. Though there is no direct evidence of variable fertility in the case of the mackerel, many analogous instances are known of seasons of greatly increased or diminished fertility in other groups of animals, of which every observant naturalist has met with many. The

young of some of our shore fishes are well known to appear in great swarms during certain seasons and to be unusually scarce in others. In some cases these swarms of young have been observed to appear as larger and larger fish for several successive years, but in other cases their very abundance has proved their destruction by attracting schools of bluefish, which very quickly depleted their ranks.

Besides the lemmings, locusts, army-worms, and many other species among land animals, we may also mention the great swarms of jelly-fishes, salpæ, etc., which appear periodically on our coasts, and the oyster, which, even aside from the question of the fixation of spat, differs greatly in this respect in different seasons. Some of these cases can be proved to be owing to the production of eggs or young in greater or less numbers, others to the greater or less destruction, through unfavorable circumstances, of eggs or young. The records of surface towings made in the neighborhood of Casco Bay show that the number of mackerel eggs present varies greatly. In 1894 they were very plentiful, while during the summer of 1897, although the eggs of other species were present in great numbers, those of the mackerel were almost entirely absent. And this was in spite of the fact that schools of mature fish entered the bay during that time. This result may have been due to the mackerel having spawned further off the coast in 1897 than in 1894. The winds influence the distribution of the eggs by moving the surface waters, but this and similar factors were eliminated in the investigations of 1897.

IV. The last theory to be considered in this connection is one deduced from the well-known wandering habits of the mackerel. Besides periodic movements toward and from the shore, and coastwise migrations which occur in spring and fall, this fish, like many other active pelagic organisms, is in the habit of wandering far and wide over the broad expanse of the North Atlantic Ocean. How extensive these more irregular movements may be in the case of particular schools of fish is not known, but it is supposed that during the periods when our fishermen meet with a scarcity the great body of fish may remain in some region hitherto unknown or inaccessible. They may either be in the open sea far off the coast or remain submerged and hidden.

Everyone knows that within the actual limits of the fishing-grounds the schools are very sensitive to changes in conditions, and so long as many of the influences which affect them remain unknown their movements seem to us to be mysterious and capricious. The fishing, both with line and seine, may be exceedingly good in certain localities for a few days, when suddenly, even in the midst of their abundance, the fish may "strike off" almost without warning, and either totally disappear, or apparently the same school reappears at some distant point.

Mackerel may be present in abundance, but refuse to school or to take the hook; or no mackerel may be visible at the surface, yet the occasional rush of schools before the onslaughts of larger predaceous fish or mammals, or other signs, may betray their whereabouts, and though plenty, none will be caught. These conditions may characterize a part or the whole of a season. During particular seasons the best fares may be taken in the spring; during others, in the fall or in midsummer. Sometimes the great catches, which have made the total for a season large, have been taken in a few weeks; sometimes the entire season has been uniform in its results, either good or bad, as the case may be.

Again, seasons may be characterized by marked differences in the distribution of the fish. One time the best catches will be secured in the Gulf of St. Lawrence; at another time in the Gulf of Maine, and, again, in the waters about Cape Cod. Some-

times the best fishing may be inshore, and the trap-owners will reap a harvest; sometimes it will be farther off the coast, and the seiners will enjoy a monopoly. It has frequently happened that for a period of years one part of the coast has been affected very differently from others. For many years the Gulf of St. Lawrence was a favorite resort of American mackerel men, but it now seldom repays the trouble of a visit. The Bay of Fundy, though formerly productive, has not supported a mackerel fishery for twenty years.

All of these facts and many others show that the movements of the mackerel are as changeable as the weather and in the present state of our knowledge just as uncertain. The success of the fleet in any given year is no certain criterion of the abundance of mackerel during that year, and it is only by taking the averages for a number of successive years that the real state of the fishery can be apprehended. There is also some direct evidence of the existence of large numbers of mackerel even in seasons which have been failures. The summer of 1877 will be remembered as one of the most disastrous that the mackerel men have known since the beginning of the century; yet in that year was seen what was probably the greatest single body of mackerel ever recorded, estimated by an experienced captain to contain 1,000,000 barrels, a number about twice as large as the entire fleet has ever taken in one year. This would seem to indicate that instead of the schools being scattered so as to come under the observation of fishermen, many of them were congregated into this vast, roving body. A few similar bodies, which might easily escape observation, would explain the apparent scarcity that year, and the successful spawning of these would account for the great host which visited Massachusetts Bay in 1880 and spread along the New England coast in the following year, when the catch was unprecedented.

Now, it has very justly been pointed out that these known facts respecting the more local movements of the mackerel, which are the cause of many of the minor variations in the catch, argue forcibly that similar fluctuations of larger degree are explained by migrations of greater scope. When the center of distribution of the mackerel hosts falls within our waters, there is a plenty; when it falls elsewhere, the degree of scarcity corresponds with its remoteness. In this connection it remains to point out that the mackerel, unlike anadromous species, is not constrained to visit the coasts by the impulse to spawn, but that this process may and frequently does take place in the open ocean, far from land.

Some of the factors which determine the movements of the great body of mackerel are known, some are unknown. Of the known factors the most important is the distribution of the pelagic organisms which serve as food for the species. But this again is determined by temperature, winds, currents, precipitation, and many other factors. Though the incompleteness of our knowledge leaves the question of variable numbers still open, we are probably safe in the tentative conclusion that migrations and variable fertility are two of the more important factors which enter into the solution of the problem. If these are among the causes, have we the remedy? We can not hope to control the migrations, though we may learn how to follow the mackerel in its wanderings or to take it from the depths. The possibility of developing new local schools by artificial means may be suggested, but this would be a weighty task, and, moreover, the same influences which led the old schools to migrate would probably affect the new. But if we set this supposition aside it remains for us to inquire if here is any probability that the desired result of uniformity in the supply can be effected by artificial propagation.

The problem is a complex one and difficult of adequate treatment. In the first place, if the truth of the above contention, that the mackerel has probably adjusted itself to the fisheries and that its numbers have in consequence maintained a fairly even balance be admitted, then it follows that each generation must produce a number of eggs sufficient, when all deductions for casualties are made, to give rise to an equal number of mature breeders. That is, the number of breeders must remain practically constant in successive generations. As in the mackerel the two sexes are about equally divided in numbers, it also follows that from all of the eggs annually produced by a female but two on the average grow to be breeding fish. The total number of eggs produced by a mackerel during the spawning season has been variously estimated at from 363,000 to 680,000. Let us fix the average number near the lower limit. There results the conclusion that about 200,000 eggs are required, under natural conditions, to produce one breeding fish.

The average annual catch of the Massachusetts fleet is about 230,000 barrels, representing roundly, according to a somewhat hasty estimate, about 32,000,000 fish of three years and older, 23,000,000 of two years, and 12,000,000 of one year. The first are all fish of breeding age, and perhaps some of the two-year-olds also are. The poor catch of the year 1877 fell below this average to the extent of about 21,000,000 fish of the largest size and 8,000,000 two-year-olds, while of younger fish the average was just equaled. Suppose that the problem is to make good this deficit by artificially propagated fish and that for the sake of clearness we leave out of consideration any disturbing factors. In order to produce this result, a sufficient number of eggs must have been handled in 1874 to produce, three years later, 21,000,000 mature fish; and in 1875 to produce, two years later, 8,000,000 fish of the size usually classed as No. 3's. And this leaves out of consideration the number of fish which would have been destroyed by the fisheries and other causes in the interval between 1874–1877, as well as the obvious fact that of those which survived only a small part would be taken by the fishermen. To make good this shortage for 1877 by the natural processes of spawning, under average conditions would require a number of eggs equal to 21,000,000 multiplied by 200,000.[1]

The year taken (1877) is, of course, an extreme case, though the present decade has seen much worse; but the goal which should be aimed at in our fishery development is to supply the entire quantity consumed in this country. Besides, the year 1874, when this hypothetical experiment in practical propagation is supposed to have been begun, was particularly favorable to its successful issue. The Massachusetts inspection passed 180,000 barrels of Nos. 1 and 2, or about 50,000,000 of fish large enough to be breeding. Now, suppose that one-half of these were males and that one-third of the fish were taken in actual spawning condition. Let us further assume that all of these 8,500,000 spawning females were actually stripped and the entire yield of eggs utilized. It is peculiar of the mackerel and many other active fishes that only a portion of the eggs produced in the season mature at one time. The mackerel yields on the average, when stripped, about 40,000 eggs. This would give a total number of eggs secured of 8,500,000 multiplied by 40,000, or 340,000,000,000.

[1] It is, of course, understood that the 21,000,000 includes fish of several ages. In the calculation all are regarded as being 3 years old, owing to the absence of any data upon which to base a separation among those of 3 years and older. The writer's personal examinations of mackerel for several years past convince him that the number of mackerel of 3 years of age captured is at least equal to all those of greater age combined, making a very liberal allowance in favor of the latter. The result of the calculation would not, therefore, be materially affected.

Now, suppose that all of these eggs were hatched, which would be a triumph of fish-culture beyond our wildest dreams, and that the 340,000,000,000 of larvæ were liberated under the usual conditions; it is evident that from now on they must be beset by the same dangers and suffer the same losses as their fellows hatched under natural conditions. In the latter case it has been shown that it takes 200,000 eggs to produce one breeding fish. As we do not know just in what period of life this destruction of 199,999 out of every 200,000 takes place, we are forced to make a guess. Let us make one which can be proved to be liberal, and suppose that 75 per cent of it occurs while the embryo is developing in the egg, during a period at most of six days, and only 25 per cent during the remainder of the three years. According to this, 50,000 newly hatched larvæ would produce one mature fish of the average spawning age. Dividing the 340,000,000,000 by 50,000, we get 6,800,000—a figure which, even under a series of hypothetical conditions ridiculously favorable, is below the desideratum. The figures given are, of course, only approximate, and in one case a liberal guess, but they give some idea of the magnitude and difficulties of the undertaking.

Let us now see what has actually been accomplished. Repeated experiments have been conducted—both abroad and especially by the United States Fish Commission for several years past—in the hope of successfully propagating the mackerel. The eggs, like those of the cod and other marine fishes, are buoyant in water of the density of the open ocean, and the same apparatus has been used in this country as for the very successful cod hatching. The several forms of Chester and McDonald tidal boxes have been used with results which have been practically uniform for all. For the purpose of automatically changing and freshening the water, the principle of a tidal rise and fall induced by an intermittingly acting siphon is used. The eggs after fertilization are placed in a receptacle, either an open box the bottom of which is made of cheesecloth, or a cylindrical jar the open end of which is closed by cheesecloth, while the bottom is perforated by a hole which permits the ingress and egress of air. The cheesecloth end of either box or jar is supported on a frame fixed at a proper point (about 2 inches below the lowest point to which the water falls) in one of the tidal boxes. By this arrangement the water within the jar or box containing the eggs is made to partake of the same movement, and part of it is drained off and replaced by fresh water with each complete tidal oscillation, while the buoyant eggs float in a layer at the surface. They do not, however, long remain so, but during the course of development become—apparently because of the gradual absorption of the oil drop—gradually heavier, and sink slowly toward the bottom. Here they lie in the midst of a mass of filth, which quickly collects, and, cut off from the light and air, sooner or later succumb. A few will usually hatch, but the larvæ do not long survive. Attempts have been made to overcome this difficulty by increasing the density of the water, or by the use of shallow dishes in which the eggs are more directly exposed to the light and air. Both of these methods gave somewhat encouraging results, but the experiments could not be carried to a conclusion. Experiments with the ordinary tidal apparatus have been frequently repeated under varying conditions, but have almost always resulted in complete failure.

The only important exception to this statement is to be found in the results reported during the past summer by Mr. Corliss, of the United States Fish Commission station at Gloucester. According to this statement, out of about 1,000,000 eggs handled 450,000 were hatched. To explain the mortality it has been suggested that this result is due to imperfect fertilization, itself the outcome of some lack of vitality in the egg

or spermatozoan; and while this is generally attributed to injuries received in capture, attention may be directed to the suggestion that the periods of scarcity may be in part due to lowered vitality and fertility of the fish. In this case it is obvious that to attempt artificial propagation while the condition lasts would be a waste of time.

But this explanation probably fails to reach the root of the matter, as a study of the spermatozoa and eggs before and immediately after fertilization indicates, by the activity of the former and the response of the latter, a good vital condition. Fertilization is very easily accomplished, and the rhythm of development is strikingly constant and simultaneous in all of the eggs of a batch. The unfavorable condition must be sought in the method of propagation, and many facts point to the conclusion that the shore waters utilized for the purpose lack the physical qualities, and the apparatus fails to supply certain important conditions requisite to the healthy development of the eggs. To this conclusion are opposed the results reported from Gloucester Station, and these, together with the partial success of experiments with water of increased density, lead to the hope that the mackerel may some day be successfully hatched.

There is, however, a further serious practical difficulty to be encountered. Even were artificial propagation as successfully accomplished with the mackerel as with the cod, and 50 per cent of the eggs handled turned out as fry, could the demands imposed by the figures given above be met? During the season of 1896 the collection of mackerel eggs was pushed with great vigor by the United States Fish Commission, with the result that about 23,000,000 eggs were taken, a number which, even if all were hatched and deposited under the most favorable conditions, would fall many times short of producing 21,000,000 fish three years later. In 1897 less than 4,000,000 were obtained, although every effort was made to conduct operations on a large scale.

These difficulties have led to the proposal that suitable arrangements be made with the captains and owners of seining vessels by which one or more spawn-takers (probably members of the crew would serve) would accompany each vessel during the spawning season. Upon the capture of a spawning school vast numbers of eggs could be taken, immediately fertilized, and turned overboard under the best natural conditions for further development.

The method has several obvious advantages—(1) great numbers of eggs which would otherwise be destroyed would be started on the way to future usefulness; (2) it could be applied at small cost, and (3) in one respect it would be a gain over the natural deposition of eggs, in that more certain fertilization would be insured. The facts upon which this last statement is based are founded not upon investigations of the mackerel, but of the cunner, where the gain is about 30 per cent.

One disadvantage of the method would be that the eggs would be endangered by contact with the waste thrown overboard during the splitting operations, and from predaceous fishes thereby attracted. Moreover, in view of the above figures, it seems futile to hope that operations could be conducted on a sufficiently large scale to be of any considerable benefit. If it ever becomes possible to confine the fry until they reach a considerable size, say until after they have assumed the adult form, then it may be possible to secure the supply of eggs in this way, to transport them to a station of great capacity and operating under conditions most favorable to the development of the species, such as would be obtainable upon an ocean-going steamer or an outlying island, and thus to bring about the desired result. But in view of the great area covered by the wanderings of the mackerel, of the vast numbers which inhabit

the ocean, and of the peculiar difficulties which have to be overcome, it seems unlikely that propagating operations conducted at a few points along the shore can ever reach that magnitude demanded in order to make them effective.

The conclusions arrived at may be summarized in the following propositions:

1. The total mackerel supply has not been proved to have diminished materially within the present century.

2. The abundance of mackerel has varied greatly within the area of operation of the American fishing fleet.

3. The minor annual variations in the catch are in part due to the local migration of the schools, and in part to the activity with which the fishery is prosecuted.

4. The more important fluctuations are of long interval, and may be represented as waves of elevation and subsidence having a period, during the present century, of usually 20 years. They are normal, in the sense of being independent of the fisheries.

5. The causes of these more important fluctuations are not fully known, but the most probable which have been suggested are, *first*, extensive migrations which carry the body of the fish to and from our shores, and *second*, variable fecundity. These, again, are the result of complex cooperating factors, some known and some unknown.

6. The need is, therefore, not to increase the total number of mackerel, but to render available a uniform portion of the supply each year, or at least to furnish a means of forecasting the prospects of each season—that is, to determine the laws of this periodicity.

7. The method of artificial propagation, even if successfully conducted, is not of proved utility for the mackerel.

8. If artificial propagation is to be of any benefit, it must be practiced on a vast scale, commensurate with the great area over which the American school of fish roams.

9. Owing to the capricious roving habits of the mackerel, it is doubtful if local schools could be established and maintained by the deposition of artificially-hatched fry in the desired localities.

10. With our present knowledge of the subject, the mode of procedure which promises the best practical results with the least expenditure would be to deposit in the water immediately after fertilization the enormous numbers of eggs which can frequently be obtained from spawning schools captured in purse seines. This would at least avoid the most serious injury which falls upon the mackerel as a result of the modern methods of fishing.

11. The problem of the mackerel can not be divorced from the problems of pelagic life in general. When the latter are solved the former, together with many other practical fishery problems, will disappear. The scientific labors of the Fish Commission and of individuals have accomplished much toward this end, but much more remains to be done. In the specific case of the mackerel there is scarcely an important question of its economy upon which fuller knowledge is not required for the practical benefit of the fisheries.

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# THE LARGE-MOUTHED BLACK BASS IN UTAH.

By JOHN SHARP,
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This excellent fish was first introduced into Utah September 8, 1890, when a carload of black bass, red-eyed perch, crappies, and sunfish (many of them spawners) was received from the Illinois River. About a fourth of these were put into the Weber River at Ogden and the remainder into Utah Lake. Of the lot planted in Utah Lake, 2,000 were large-mouthed black bass. Of those planted in the Weber River at Ogden little has been said or heard, but the Utah Lake fish have developed very satisfactorily. They were not allowed to be taken in any manner for three years after their introduction, and at the expiration of the legislative period of protection it was evident that the large mouthed bass had increased very rapidly and grown to a fairly good size. A few were taken in the fall of 1893, the largest weighing 3 pounds, the average being about 1 pound. In 1894 they began to be taken regularly for domestic use and commercial purposes—about 30,000 pounds per annum being reported by the commercial fishermen and dealers—and, including those taken by sportsmen and others for family use, I believe I would be within conservative bounds in saying that Utah Lake has produced annually 40,000 pounds of Oswego bass since 1894, without taking into consideration those taken for propagating purposes in this and neighboring States. I am told that they are increasing rapidly and that there are many millions in the lake.

The annual growth of the largest specimens taken seems to be about 1 pound. The largest fish taken in 1895 weighed 4½ pounds. In 1896 the largest weighed 5¾ pounds and was about 18 inches long. In 1897 the heaviest fish taken weighed 6½ pounds and was about 19 inches in length. Not having had any experience with this fish before its introduction here, the larger sizes seem to me to grow extremely stocky, their length not appearing to be more than about twice their depth. This is no doubt a marked characteristic of the species where favorable conditions exist for its perfect growth and development.

This Utah lake, which has proven to be such an excellent nursery for the Oswego bass, is situated near the center of the State and has an area of about 200 square miles, with an average depth of 10 to 15 feet, and lies at an altitude of 4,499 feet above mean sea level. The surface temperature of the water during the summer months I estimate will range from 60 to 65° F. I have not learned of any extended temperature tests of the water having been made to determine the average temperature.

The lake has an approximate length of 20 miles north and south, with an average width of about 10 miles east and west, and is fed by a number of springs and mountain streams of varying size, with one of considerable volume, the Provo or Timpanogos River. The water running into the lake comes from streams draining from the Wasatch

range of mountains immediately on the eastern side of the lake, and in consequence the lake bottom on that side is of a mud or silt character from deposits of inflowing streams.

The lake is abundantly supplied with native common fishes, chub, mullet, some mountain herring (Williamson's whitefish), three or four varieties of sucker, and minnows, with, unfortunately, an ever-increasing supply of carp, introduced here in 1886. It is also fairly well stocked with a large-growing native trout which frequents the inflowing and connecting streams in April, May, and June to spawn, and which I believe is classified as "*Salmo mykiss virginalis*." In the early settlement of the State this grand fish was almost phenomenally abundant in the lake and connecting streams. It is authentically reported that as much as 3,700 pounds of it have been taken at a single haul with a seine not exceeding 200 yards long, with many individual specimens weighing 25 pounds each. We do not now find any of these trout so large, but some are taken weighing 15 pounds, and since the taking of trout and bass is confined by law to the usual method of angling or trolling with hook and line only, I hope to again see some of these native Utah Lake trout attain to their old-time size.

The rapid increase and growth of the large-mouthed bass in this lake are no doubt due to the abundant supply of the native common fish together with a varied supply of fresh-water crustacea upon which they prey, with a depth of water and with water vegetation suitable to their requirements. I believe that all the conditions favorable to the perfect growth and development of the Oswego bass exist naturally in this lake, especially after they have attained the first year's growth. I have noticed, however, that the fry for the first year do not grow so rapidly in this lake as in some other smaller bodies of water to which they have been transplanted from this lake. Of four or five thousand fry which I had taken before the spawning season of 1897 for distribution in different parts of the State, the very large majority were from 2½ to 4 inches in length only. These were no doubt hatched the previous season and could not have been less than six to eight months old.

In marked contrast to this apparently slow growth of the bass fry in Utah Lake the first year, in the Mount Nebo reservoir an almost phenomenal growth of the fry from the first planting was shown the first season. This reservoir is situated about 15 miles south of the lake, and was created by the construction of a masonry dam across Salt Creek at its exit from the Nephi Valley, through which it flows into Goshen Valley and thence finds its way into Utah Lake, or did so before being appropriated for irrigation purposes. This is a small sluggish stream of clear and slightly brackish water, averaging about 10 feet wide and well supplied with native minnows before the reservoir was created. This reservoir is about 5 miles long with an average width of ½ mile, and of varying depth from nothing to 15 feet in places, the water covering entirely new ground with the exception of the old creek channel. About the 1st of May, 1896, the parties controlling this reservoir made application for and received 90 large spawning bass and planted them here in this small body of water. These fish evidently began to spawn soon after being planted, for in about four months after the planting the place seemed to be alive with bass fry of very large size. It was estimated that there could not be less than 500,000 of these young fish. Having heard of this wonderful plant, I visited the site seven months after the plant was made, but unfortunately for my investigation a cold snap had partly frozen the pond over and driven the fish into the deep water so that I could not have an opportunity of making a personal estimate as to numbers. I was fortunate, however, in having a

close inspection of about 50,000 which had escaped through the dam gate and were penned in the channel immediately below. A dozen of the largest of these were taken with an improvised dip net. In contrast with the fry of the same or a greater age in Utah Lake, these had attained a superior growth of at least twice the length and ten times in weight. They would average 6 inches in length and weigh nearly ½ pound each, being very stocky. I can not account for this vast difference in the growth of the young bass the first year in these two places, unless it might be that in the new reservoir there are no large fish of other species to interfere with or disturb them; and the new ground perhaps furnished abundant food in the development of worms and other minute animal life exactly suited to their age and condition. I shall watch this reservoir plant with considerable interest to see how long the superior growth may continue.

Recognizing the superior adaptability of this splendid fish for the lakes and ponds of the lower valleys of this State, I recommended a legislative appropriation to stock these waters with large-mouthed bass, and the general assembly in March, 1897, appropriated a sum sufficient to stock all the suitable waters of the State. Arrangements were therefore made to catch the fish out of Utah Lake and place them in small ponds near the railway, preparatory to shipment to the various places of planting, and by May 4, 1897, enough had been taken to make a large carload, which was shipped on that date to Bear River and Bear Lake in the northern part of the State. This consignment consisted of 2,500 fish in all, 450 being large spawners averaging close to 2½ pounds each. Of this lot, 100 spawners and 600 yearling fry were deposited in Bear River at various points in Box Elder and Cache counties, and the remainder taken to Bear Lake and planted at a number of places on the eastern side of the lake embracing a range of about 25 miles in length. This beautiful sheet of water has approximately the same surface area and dimensions as Utah Lake, with the elongated axis north and south in a similar manner, and both lakes are flanked on three sides by majestic mountains. The southern and main part of Bear Lake has a beautiful sandy, gravelly, and rocky bottom and shores, with water as clear and limpid as glass, and attaining a depth of 250 feet in places, with the summer temperature on the surface ranging quite 10° F. below that of Utah Lake. It lies in the extreme northeast corner of the State, about 300 miles north of Utah Lake, and at an altitude of 5,911 feet above mean sea level, and is fed mostly by short cold streams flowing into it from the snow-clad mountains on the west. The common fishes are more numerous here than in Utah Lake, with two species of large growing trout, locally known as salmon trout (which frequent the inflowing streams to spawn) and the bluenose trout, which I am told spawns in the lake. Some of these trout in early times, before the use of seines and gill nets for commercial purposes, are reported to have attained the weight of 30 pounds.

This lake is about equally divided between Utah and Idaho, the east and west dividing line of the two States cutting the lake in about equal proportions, so that in stocking it with the black bass, Idaho receives as much benefit as Utah, which we do not at all begrudge. Theoretically this lake should produce a better quality of bass than Utah Lake. It apparently has equal if not superior food and spawning facilities, with a much purer quality of water that should impart a better flavor to the fish. The question of the considerably lower temperature of the water may and perhaps will prove to be an important factor for good or evil in the growth and development of this valuable food and game fish in this lake, which the next few years will no doubt

demonstrate. I feel quite sanguine, however, that this goodly plant of the Oswego black bass will prove successful, and of incalculable benefit to the northern part of Utah and the southern portion of Idaho.

This being the largest and most important individual plant to be made in the State, it received the first attention; and after its successful accomplishment, it was deemed advisable to defer the plantings in the southern part of the State till the cool weather in the fall, and for the further reason that the spawning time was dangerously near for successful catching and transportation. Further stocking of the State waters was therefore postponed until the 30th of October, when I took a shipment of 130 large spawners, ranging from 1 to 5 pounds weight, and 1,100 yearling fry to Richfield on the Sevier River in the central-southern part of the State and planted them in a clear, sluggish stream of spring water tributary to the Sevier River. This spring stream is 15 to 20 feet wide and has its source in a succession of connected spring ponds and lakelets of varying moderate depth, fringed and interspersed with tules, flags, water cress, moss, and other vegetation, and covering an area of probably 200 to 300 acres. It is an ideal small place for the bass, and the whole shipment was planted here and designed as a stocking plant for this section. Most of the water to be stocked is of a pond character, with generally small and slowly flowing streams, the Sevier River being perhaps an exception.

This stream, although the main drainage avenue of this part of the State, can hardly aspire to the dignity of a river, its channel being from 30 to 50 yards wide only. For one or two months in the spring of the year, however, the melting snows from the mountains along its course and the mountain streams tributary to it swell its volume to the dimensions and character of a torrent or a small river, but in the summer months the channel is drained almost dry in places for irrigating purposes. Nevertheless the water drains and seeps back again into the channel, giving long stretches of water with hardly a perceptible current. The bass might do fairly well here, as the common fish abound everywhere in these waters, and the upper portion of the stream has a goodly supply of the same species of trout found in Utah Lake, and all the streams tributary to it and where its source originates are thronged with mountain trout.

Sevier River has its source in the mountains forming the rim of the Great Salt Lake Basin, near the southern boundary line of the State, and flows thence 200 miles in a northeasterly course to a point at Gunnison in Sanpete County, where the course changes to northwesterly for about 40 miles, and again to westerly and southwesterly for about 50 miles; then, after flowing through the entire length of the Sevier Valley and passing through six counties, it finally discharges into Sevier Lake in Millard County. This lake has no outlet and contains too much saline matter for the existence of fish life; but there are a number of square miles of connected lagoon lakelets near the mouth of the river on either side before reaching the main saline lake, where the water is fairly good, with an abundant supply of all the native common fishes, and carp innumerable. Here I have high hopes that the bass will do well; and these waters, together with a few other smaller patches in this locality, were the next and last to claim our stocking attention for this season.

On the 12th of November our last carload, consisting of 200 large spawners and 1,800 yearling fry, was started over the Oregon Short Line Railway from Utah Lake at Provo. At Juab station, 60 miles south from Provo, 45 large spawners were taken out and sent by wagon to Scipio Lake, 20 miles southwesterly from this point. The

lake has an area of 1,000 to 1,500 acres, well supplied with native common fish and carp. Chicken Creek Lake, 3 miles south of Juab station, is a patch of clear spring water covering an area of 500 acres or more, with every indication of being an ideal small place for bass, with excellent spawning conditions and plenty of food. The railway passing close to the shore of this lake at one point, I had the train stopped a few minutes in passing and set 16 large spawners at liberty here. Passing on about 6 miles farther, to where the Sevier River is first encountered on this line, a plant of 400 yearling fry was made, after which the bulk of the shipment was taken on to Deseret and planted in the lagoon lakelets, near the mouth of the Sevier River. Forty-five large spawners were planted in Clear Lake, about 15 miles south of this point. This lake contains only about 2,000 to 3,000 acres of water suitable for bass culture, but I expect to see larger bass produced here than at any other place in the State. The water, issuing from large springs bordering the lake, is very slightly brackish and clear as crystal, with a fairly uniform temperature of 55° to 60° F. throughout the year. Minnows and common fish are superabundant here, and carp planted here six or seven years ago have grown very large, some of them, I am told, weighing 30 to 40 pounds.

This being our last stocking shipment for the season of 1897, a recapitulation will show that nearly 800 large spawners, averaging nearly 2½ pounds each, and 5,000 yearling fry were distributed by the State fish and game department in the public waters, covering a longitudinal area of about 450 miles, giving a long, if not a wide, distribution throughout the State to this superior food and game fish. In addition to the State plantings, 750 large spawners were furnished to applicants for private pond cultivation throughout the State during the season, and 5,000 yearling fry to the State of Colorado for distribution in public waters of that State, making a total of over 11,000 bass distributed for propagating purposes from Utah Lake during the season of 1897.

A few words as to the method of transportation and care in transit may not be out of place. As we had no specially constructed tank car for the purpose, barrel receptacles had to be resorted to; 50 barrels of 40 to 50 gallon capacity each were placed in a large baggage car, kindly furnished by the Short Line Railway Company. The fish were taken with small nets from the ponds close by, put into barrels of fresh water in wagons waiting to receive and convey them a short distance to the car, where they were again transferred from the barrels in the wagons to the barrels in the car, which also contained fresh water to about four-fifths of their capacity. From 10 to 15 of the large spawners were all that was deemed advisable to put in a barrel, and 300 to 400 fry in barrels of the same capacity. Everything was timed to make as close connection as possible with the north-bound express train. This was our first experience in transporting the fish in carload lots such a long distance; the undertaking was therefore largely experimental, and at this season of the year (May 4) was attended with considerable hazard.

Air-pumps and hand-bellows with rubber tube attachments to reach the bottom of barrels for aerating the water had been provided, together with buckets for the same purpose. We soon learned that the buckets were of far greater practical utility than all the other contrivances. When the fish showed signs of discomfort by coming to the top of the water, a few applications of the bucket would send them down again. This was done by dipping the water out of the barrels and pouring it back again from as great a height as possible by the attendants, and I observed that a quick and violent return of the whole bucketful had a much better effect than a slow and gentle

pouring. Sometimes if a barrel chanced to be overlooked a little too long and the fish were particularly uncomfortable, it would take from 8 to 12 bucketfuls dipped out and poured back as rapidly and violently as possible to make them easy again. I found that this performance had to be repeated with each barrel once every 30 minutes to be safe, showing that these large fish especially consume the air out of the water very rapidly.

After an all-night run of fifteen hours in the car, the nearest station to Bear Lake was reached, and here eight wagons were waiting to take the cargo to the lake, the nearest point being about 12 miles south of the railway. The barrels containing the fish were soon transferred to the wagons and the lake was reached about noon, and some of the fish planted at the first favorable place and opportunity. Three-fourths of the lot, however, was taken to the extreme southern end of the lake and planted there at 9 o'clock p. m., after a 40-mile wagon-haul and thirty hours in the barrels. The only change of water was during the first four hours of the trip, at Salt Lake City and Ogden, where less than half the water was taken out and replaced with a fresh supply. The lack of fresh water, therefore, had to be compensated by the vigorous application of the water-buckets to supply sufficient aeration. An observation made during the long wagon-haul should not be omitted. Wagons with springs and some without springs were used, and I noticed that the fish in the wagons without springs seemed to be in a better condition than those in the spring wagons; and in going over rough places in the road the water showed less tendency to slop over and spill out.

After getting the last of this consignment of bass into the waters of Bear Lake with a loss of not to exceed 7 per cent in transit, and all in good lively condition, I felt very greatly relieved, for I expected to lose a much larger percentage. The shipments to the southern part of the State in the cool months of autumn were made with less than 1 per cent loss, thus showing that the cool weather in the fall of the year is the best time to transplant and distribute this fish in Utah. From the high parental instinct and other good qualities of this great fish, I am strongly of the opinion that it is the coming fish for pond cultivation in this State.

I wish to express the highest appreciation of the conduct of our local railroads, the Oregon Short Line and the Rio Grande Western railways, in furnishing cars and free transportation for this State distribution of the black bass, and also to acknowledge the important service rendered by the United States Commission of Fish and Fisheries at Washington in first introducing the large-mouthed black bass in Utah.

SALT LAKE CITY, UTAH.

# FLORIDA FUR-FARMING.

By J. M. WILLSON, Jr.

In discussing the water products of Florida fur farming is worthy of consideration. That Florida produces a fur of high grade will doubtless be a surprise to many, yet thousands of dollars' worth of otter skins are shipped from the State annually. As a subject for water-farming the American otter occupies a position distinct and wholly his own. Terrestrial and aquatic, he is an interesting anomaly.

From the beginning of time the skins of animals have contributed largely to the comfort of mankind. The first garments ever worn by the human race were made of skins and fashioned by the hand of the Creator. "Unto Adam also and to his wife did the Lord God make coats of skins, and clothed them." (Genesis iii, 21.) In latter days the employment of so much fur for personal adornment has led to the wanton destruction of the teeming millions of fur-bearing animals. From the constant reports of the work of the deadly pelagic sealers and the consequent extermination of the seal many questions arise and many theories are advanced as to the furs of the future.

Leading furriers in New York say that the price of furs during the past few years has advanced at least 150 per cent, and that the time is rapidly approaching when seal will be a luxury which only the very rich can procure. Either the sealing-grounds must be repleted or the future wearers of fine fur must pay fabulous prices for the privilege of being kept elegantly comfortable, or else they must resort to cheaper skins.

This is a scientific age and the domain of investigation is visibly broadening. The main idea of the majority of mankind seems to be to discover new fields for labor and investment, and the sequel to the "story of the seal-skin sack" is yet to be revealed.

The fur of the American otter ranks among high-priced furs, of which, too, any quantity can be sold, quotations on Florida otter skins (cased) ranging from $5 to $8 each. In anticipation of a coming deficiency in the supply of fine furs the subject of breeding the Florida otter for its fur has been investigated; and Florida, as the natural haunt of the little animal, offers a field for experiment. The subject bewilders, then fascinates.

The Florida otter is fast being exterminated; but in the swamps of the Everglades, where none but the daring hunter or the stealthy-footed Seminole wanders, the little animal is still found. Very little, if anything, of the habits of the otter is known to science. Every effort has been exhausted in attempts to collect useful data on the character of this quaint little denizen of the swamps. Scientific journals and the encyclopedias add little to the research. From the trapper and from the hunter, who in pursuit of their callings have observed the wary otter, the most valuable information has been gleaned.

Many objections have been raised by the incredulous as to the practicability of raising the otter for a pecuniary benefit, but each objection in its turn has been met. Neither the excessive rains nor the long droughts, the hot summer suns nor the frosts of winter, will affect the industry; neither would the products have to be rushed to market. The pelts, after casing, are non-perishable; the demand for the fur is greater than the supply, and a maximum price could always be obtained by the fur being taken only at its prime, while the transportation charges for conveying the product to market would be very small. In the manufactured garments the quotations on seal are only about 25 to 30 per cent higher than on the natural otter.

While the impression is abroad that the skins of southern animals have a decided disadvantage in the market as to quality, it is learned from leading New York furriers that the Florida otter compares favorably with the furs of more northern latitudes; and, further, that any quantity of Florida pelts may be sold in New York, and that even during the past depression in business otter fur held its own, which is the best proof of its stability.

The otter is most easily domesticated, having a marked degree of intelligence and acute perceptions; he is cunning and affectionate, and as playful as a kitten. In his native haunts he is one of the shyest of wild animals, but in the domain of civilization is bold, venturesome, and ever ready to make friends and foes alike. Few animals equal the otter in agility; his long, flexible body is enveloped in a skin so loose that he almost seems able to turn himself over in it; he can dart or turn in the water with as much celerity as a fish, and is therefore an expert swimmer. Small fish he eats in the water, while large ones he brings out on land to devour.

In raising the otter for his fur, every arrangement should be perfected to conform to the natural surroundings of the animal, the idea being simply to assist nature. Here in Florida the otter will grow and flourish with little or no attention. At the age of twelve months he is full-grown, and the fur is at its prime. The weight of a full-grown otter varies from 20 to 25 pounds. The female has young once a year, the number varying from three to five, although instances are known of eight young having been found with the mother.

It is confidently believed by those who have studied the subject, that the semi-domesticated otter, when well fed and cared for, will mature faster and rear a larger number of young than in a wild state. With the success attending the experiment of raising the otters which are now on exhibition at this Congress, the mind may quickly picture a ranch for this amphibious herd, both ideal and picturesque. The rich tropical foliage, the bird notes, and the dreamy southern sky are there; on the north shore of the large fresh-water lake are dense cypress forests; whitecaps play upon the waters; wild duck, crane, and quail are numerous. One side of the lake is covered with weeds and grasses reaching back and extending over a low, marshy ground, which is thickly dotted with clumps of bushes and cypress trees. The cypress knees, being very large and hollow, form ideal breeding-homes for the otter, which they enter by a passage underneath the surface of the water, forming a safe harbor and a secure retreat from all enemies. An abundance of food supply at small cost is an important point to be considered; and, after investigation, German carp has been decided upon as the most desirable fish for that purpose. In 1895, a supply of scale and leather carp was procured from the U. S. Fish Commission, and deposited in two fresh-water lakes, covering an area of about 60 acres.

While carp have recently been pronounced by the fish commissioners of several States an unmitigated nuisance, compared with which all the plagues of Egypt were but a mild chastisement, the very objection to the aquatic stranger—that it multiplies like some miserable species of insect—only adds to its value as a food supply for otter-farming. The otter being aquatic, his natural prey for the most part is found in the water—fish, frogs, snakes, etc. In his domesticated state he learns to eat almost anything—meat, cooked vegetables, fruits, bread, etc. Carp may be fed if necessary on different kinds of vegetables; thus between the carp and the otter all surplus crops could be utilized.

According to statistics, the young carp, with plenty of food, will attain the large growth of from 3 to 6 pounds in one year. Nature has supplied the food for carp in Florida waters in the greatest quantities; the water-lily, bonnet-pad, grasses, and tender roots, which European waters do not possess, abound in the lakes. The water hyacinth, which has become such a menace to navigation in the St. Johns River, if propagated in a carp pond, would supply food for all time to come. In order that the carp shall be provided with a variety of food, a quantity of wild rice (*Zizania aquatica*), may be sown around the edge of the lake and in the muddy bottoms. To clear the lake of alligators would be a necessary precaution; and with fish, turtle, etc., this aquatic herd of fur-bearing animals would grow and flourish.

The otter is a great climber, and, from the experience gathered from the study of the captive otter, it has been demonstrated that a particular kind of inclosure is required. The fence should be a combination of wire and plank, or a solid wall fence, set below the surface of the ground and extending beyond the lake on all sides. With a large inclosure (a space of 20 to 40 or 60 acres being desirable) conforming to the natural haunts of the animal, this aquatic herd need not feel their captivity, but fish and leap and play and rear their young as naturally as if they were in their Everglade haunts.

KISSIMMEE, FLORIDA.

# THE

# FRESH-WATER PEARLS AND PEARL FISHERIES

OF

# THE UNITED STATES.

BY

GEORGE F. KUNZ.

SHELLS OF FRESH-WATER MUSSEL (Unio crassidens).

Mississippi River.

# 9.—THE FRESH-WATER PEARLS AND PEARL FISHERIES OF THE UNITED STATES.

By GEORGE F. KUNZ.

## THE ORIGIN, NATURE, AND VALUE OF PEARLS.

Pearls are lustrous concretions, consisting essentially of carbonate of lime, interstratified with animal membrane, found in the shells of certain mollusks. They are believed to be the result of an abnormal secretory process caused by an irritation of the mantle of the mollusk, consequent on accident, disease, or the intrusion into the shell of some foreign body, as a grain of sand, an egg of the mollusk itself, or perhaps some cercarian parasite. It has also been suggested that an excess of carbonate of lime in the water may cause the development of pearls. Accepting the former theory as the more probable, it is easy to understand how some foreign body, which the mollusk is unable to expel, becomes encysted or covered as by a capsule, and gradually thickens, assuming various forms—round, elongated, mallet-shaped, sometimes as regular as though turned in a lathe. Mr. Charles L. Tiffany, who has given considerable attention to this subject, suggests that the mollusk continually revolves the inclosed particle in its efforts to rid itself of the irritation, or possibly that its formation is due to a natural motion, which is accelerated by the intruding body.

In regard to the formation of pearls, the following general statements may be made: Whatever may be the cause or the process of their production, these interior concretions may occur in almost any molluscan shells, though they are chiefly confined to certain groups, and their color and luster depend upon those of the shell interior adjacent to which they are formed. Thus the pink conch of the West Indies yields the beautiful rose-colored pearls, while those of the common oyster and clam are dead white or dark purple, according to their proximity to the part of the mantle which secretes the white or the dark portion of the shell. The true pearly or nacreous iridescent interior belongs to only a few families of mollusks, and in these alone can pearls proper be formed at all, while in point of fact they are actually obtained only from a very few genera.

The families with iridescent interior layers are the following: Among cephalopods, the nautilus and the ammonites, the latter wholly fossil. In both these groups the removal of the outer layers of the shell reveals the splendid pearly surface beneath. Modern nautilus shells are often "cleaned" with dilute acid to fit them for use as ornaments; and frequently this is done partially, elaborate patterns being formed by leaving parts of the white middle layers to contrast with the pearly ground. Among the fossil ammonites the same effect is produced very often naturally by decay of the outer layers, and no artificial pearl work can compare with the richness of color—literally "rainbow-hued"—that is presented by many of these fossils from Jurassic

and Cretaceous deposits. Among the gasteropods the pearly groups are the turbos and haliotes or abalones, in both of which, but especially in the latter, there is a frequent occurrence of green iridescence. Shells of both these families are "cleaned" with acids for use as ornaments, and the exquisite green Haliotis material is extensively used in the arts under the name of abalone.

The pearls of commerce, however, are almost wholly obtained from bivalve (lamellibranch) shells, of which the following families have a nacreous lining: *Aviculidæ*, *Mytilidæ*, and *Unionidæ*, the last being a fresh-water group, also known as the *Naiades*. A few genera of other families are also brilliantly pearly, but need not be here discussed. The true pearl oyster (*Meleagrina*) found in the Pacific and Indian oceans belongs to the first of these families, and has from time immemorial yielded the bulk of commercial pearls, while its large and thick shell furnishes the mother-of-pearl for countless ornamental purposes. The *Naiades* are of particular interest in this country, as it is in North America that this group is most abundant. Several hundred species of *Unio*, *Anodon*, etc., have been found in our great rivers and lakes, and the Mississippi basin teems with them, in forms, for the most part, quite distinct from those of the Atlantic watershed and of the Old World. The Unios, while all iridescent, vary greatly in tint, exhibiting many delicate shades of pink, brown, purple, etc., as well as white. The rivers of Europe, of Mesopotamia, and of China also yield large numbers of Unios, while other allied genera (*Hyria* and *Castalia*) represent the family in the Amazon basin of South America.

In the fresh-water species the two valves are alike in size and shape, while in some of the marine families they differ, as is well seen in the common oyster. Each of the valves consists of two parts, the epidermis and the shell proper, the latter composed of numerous layers. The epidermis, which resembles horn, consists chiefly of a brown or yellow substance called "conchioline," soluble in caustic alkalies; beneath this is the outer portion of the shell proper, the prism stratum, consisting of layers formed of minute prisms arranged vertically to the layers and the shell surface; and, third, the interior nacre layer, composed of finely folded leaves parallel to the shell surface. The last two strata consist chiefly of carbonate of lime. These formations may be seen in transverse cuttings and microscopic sections. The soft internal parts of these mollusks are covered by a thin, delicate membrane called the mantle, from the surface and particularly from the outer edges of which material is excreted to form the inner layers of the shell. Whenever, by accidental injury, disease, or intrusion of foreign substances, local irritation is set up in these tissues, the effect is to produce an increased secretion of the nacreous matter at this point, resulting in the formation of pearls or pearly concretions.

Pearls are of several distinct kinds, differing in shape and perhaps, as elsewhere suggested, in origin. These are (first) what are known as "free" pearls—those that are found loose and separate between the folds or layers of the mantle and gills, or between the latter and the body of the mollusk. These comprise most of the true spherical pearls, as also many that are ovate, pear-shaped, and irregular. Then there are the pearls found between the mantle and the valves of the shell; these, if free at all, are apt to be hemispherical, or in any case flattened on the side toward the shell, while very often they are attached more or less to the valve by a deposit of the pearly secretion. In the region of the hinge these become extremely irregular in shape and often greatly elongated, forming a third kind, known as hinge pearls, baroques, etc.

FRESH-WATER MUSSEL, *Margaritana margaritifera*, SHOWING PEARL INCLUDED BETWEEN MANTLE AND SHELL, IN THE LOWER RIGHT-HAND CORNER.

Specimen prepared by V. Frič, of Prague. From Botova River, Bohemia.

As many as a hundred small pearls have been found in a single shell, but as a rule these have little or no value. Very curious nacreous groups made of many small pieces are at times found attached to the hinge, but these are generally without sufficient luster to be of value, and are rarely collected. These groups are caused by the conglomeration of many small pearls cemented by a deposit of nacre, and are often half an inch across.

The same causes and operations that result in the production of pearls also produce in a modified way the tuberculose or knob-like protuberances and irregularities of surface that are frequently seen on the pearly inner faces of the valves and projecting therefrom. The flatter or less pronounced form of these nacreous excrescences are often called "blister pearls," because of their resemblance to vesicular eruptions or to water-blisters caused by burns.

When the growth of the pearl is abnormally strong, the pressure which it exerts on the outer wall of this tissue pocket becomes so powerful that the pocket is absorbed on the side toward the shell, bringing the hard pearl directly against the latter. It then becomes impossible for the pearl to grow any more at the point of contact, for there is no tissue to secrete the lime substance; but it grows on the rest of the surface, and the thickening layers, as they are formed, pass directly into the nacre layers on the inside of the shell and thicken the shell itself. Through these overlayers the pearl is connected with the shell as though by different layers of covering cloths. At first it clings to the shell at one point only, afterwards enlarging the area of its adhesion. In this manner twin or united pearls are formed.

All these varied kinds are found in the marine pearl oysters as well; but the fresh-water mollusks have the additional beauty of great variety of tints and of partial transparency in their nacre. In color the Unio pearls present an extended series of shades from dead opaque white, having but little value, through various tints of pink, yellow, and salmon, or a faint purple, passing to a bright red so closely resembling a drop of molten copper as almost to deceive the eye. Some are very light green and brown, others rose-color, and still others are pale steel-blue, russet, and purplish-brown. In addition to their color and luster, they are beautifully iridescent. The white and the pink pearls are exceedingly handsome, and the finest, owing to their delicate sheen or layers, are at times more lustrous than even the best oriental pearls. This luster is increased by their greater transparency, and a really fine white, pink, yellow, or iridescent pearl is often quite translucent. They are found also in many odd and remarkable shapes.

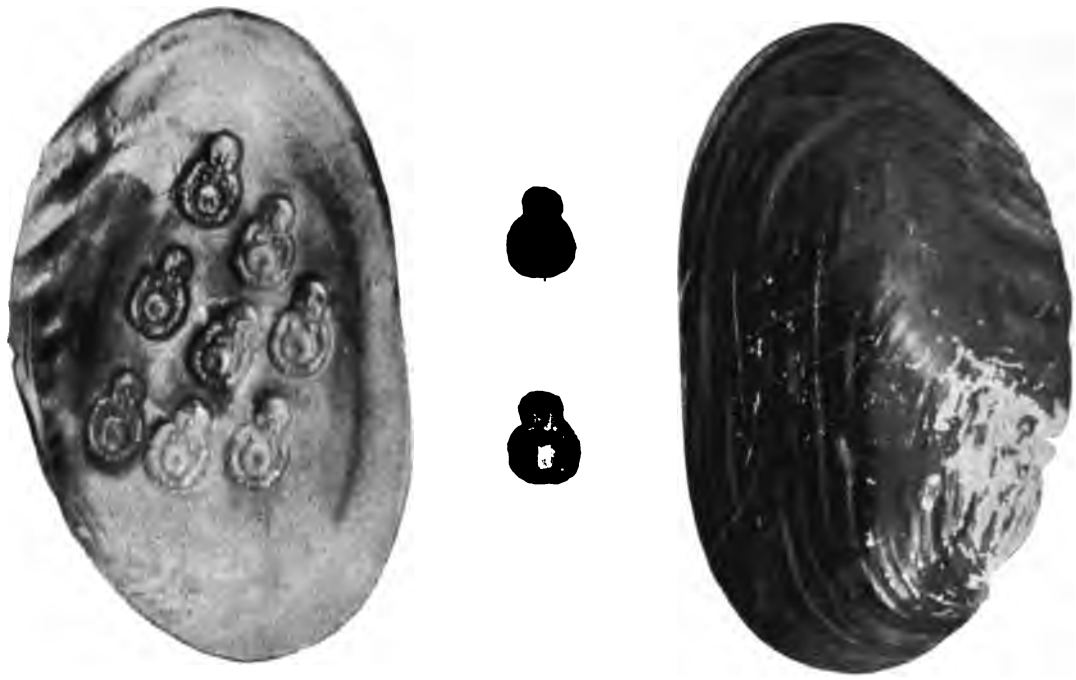
Elongated fish-like forms found near the hinge of the shell and called hinge baroque pearls are abundant. Others, with a slight addition of gold and enamel, may be made to represent human and animal heads, bat and bird wings, and similar objects. Mallet-shaped pearls are found with fine color and luster at each end, though generally with opaque sides; also, grouped or bunched masses of the pearly nacre, made up of from one to over one hundred distinct pearls in fanciful shapes, are of occasional occurrence. Feather-like forms with curiously raised points and an odd rounded variety with raised pitted markings are quite abundant. A pearl was mounted in this country that strikingly resembled the bust of Michael Angelo; and a number of unique designs have been made of baroques, similar to those mounted by Dinglinger and exhibited in the Green Vaults at Dresden. Although the pearls used here have not been as large as those shown in Dresden, greater taste has been employed in mounting them. The variety of the Unio forms being so great, an artist

appearance on one side. It was so set that the imperfection was all below t
ing. When applauding at the opera one evening the pearl was broke
examination it was found to consist of a very thin nacreous layer, inside of
nothing but a hard, white, greasy clay. (See plate X; enlarged 3 diameter

Whatever be the method of their formation, it would seem that pearls a
at the expense of the shell, for the substance necessary to their growth is d
sources which normally secrete the shell. Hence the presence of a pearl
times be detected on the outside of the shell. Normal appearing shells rare
pearls, while on the other hand those that are deformed often contain pear
beauty. There are three indications on which pearl-fishers to some exte
detecting the presence of pearls from the outward aspect of the shell.
first, the thread—that is, a recess or elevation extending from the vertex to
second, the kidney shape of the shell—that is, an indentation on the ventral
third, the contortion of both valves toward the middle plane of the animal.

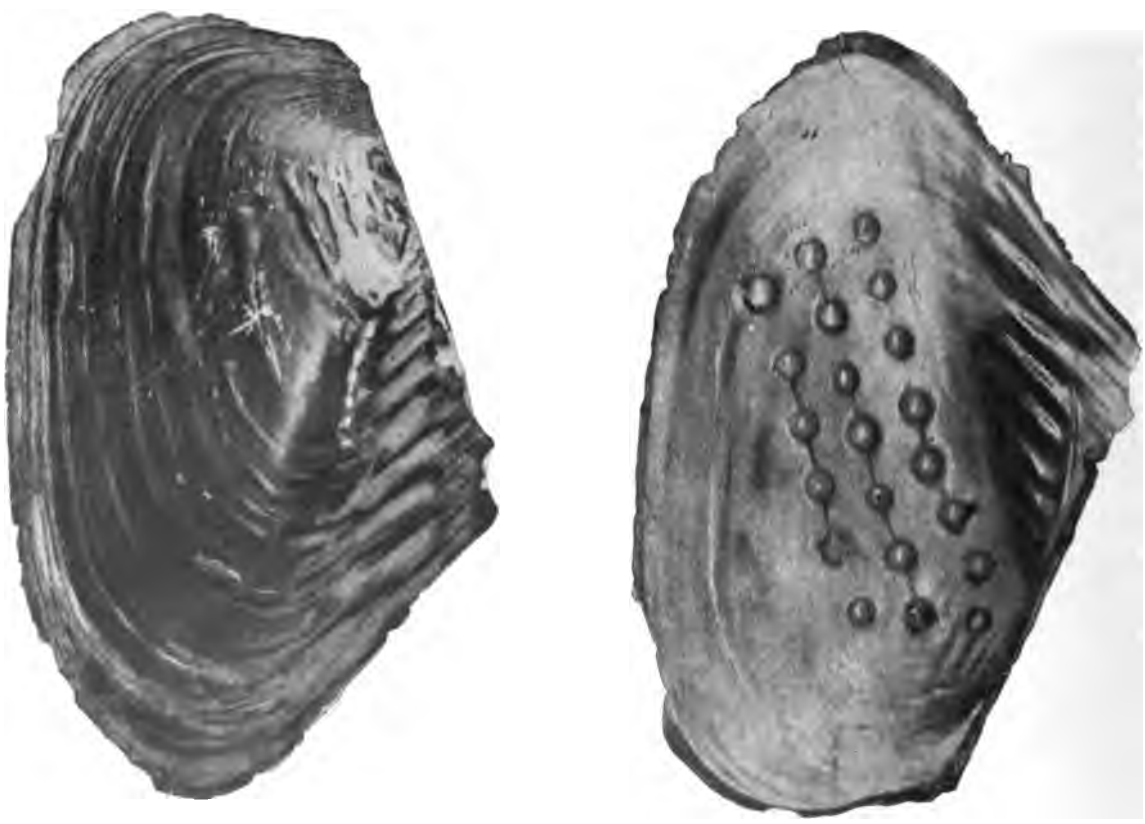
The precise manner in which pearls are formed is a matter of some un
and several views are held, all of which have some apparent basis in obse
There are three principal theories, viz, that the special and unusual secret
pearly material at certain points is due, first, to disease; second, to acciden
and third, to the intrusion of foreign substances of some kind into the s
first view is sustained by the fact that pearl production seems to occur
streams and at certain periods especially, as though it were a result of som
condition affecting the shells largely at certain times, like an epidemic dis
it has also a slight analogy in the development of calculi and of gout
animals. The second theory, that of injury or accident, is largely based
frequent occurrence of pearls in shells that have an aspect of distortion or
This, however, is very far from being universal, and might also be a result
rather than of accident. The third view, that pearls are caused by the in
foreign bodies, which the mollusk, if unable to expel, covers over and inc
the pearly secretion, has the evidence of actual demonstration in many inst
is unquestionably true to a large extent. It may be, however, that the othe
particularly that of disease, are also true in some degree, and that pear
formed in either of several ways.

Still another view is held by some, which lies rather between the first a
those already mentioned, viz, that the nucleus of a pearl is an egg of the
which has for some reason failed to be expelled in the usual manner. The



DIPSAS PLICATUS, INTERIOR AND EXTERIOR, INTERIOR CONTAINING TINFOIL FIGURES OF BUDDHA.

Four inches long. Pearl-coated figure of Buddha, obverse and reverse, showing concave depression originally filled with tinfoil or wax.



DIPSAS PLICATUS, CONTAINING THREE STRINGS OF BEADS WITH A PEARLY COATING.

Both from temples in Souchow, China.

an abnormal secretion of the pearl material in the adjacent tissues. It is evident also that pearls of this kind could be formed only in the female shells, and this point is one that requires further investigation.

The evidence for the intrusion theory may be briefly reviewed as follows: Cases are known among the marine pearl oysters in which small fish entering the open valves of the large shell have worked their way in between the shell and the mantle and been unable to escape. They have then been coated over with the pearl secretion and fastened down thereby to the inner surface of the valve. When subsequently the shell has been gathered and opened by pearl-fishers the form of the little intruder has been found distinctly preserved in pearly relief on the interior of the shell. Other similar instances are also known.

Among many remarkable specimens of pearls and pearl shells exhibited at the World's Fair at Chicago in 1893, and now in the Field Columbian Museum, were several examples of this kind. One of these was a small piece of true mother-of-pearl shell two-fifths of an inch in length, which broke while undergoing the operation of being made into a button, revealing a small inclosed crab immediately below the blister. Among fresh-water shells the same fact has been indicated in a few instances—one where a crayfish has been thus inclosed beneath a pearly covering, and another where a Unio, from Long Island, contained an insect entombed in the same way.

There are, however, even more positive proofs. It has long been the habit of the Chinese to produce artificial pearl objects by introducing little flat metallic figures, usually images of Buddha, between the valves and the mantle of a large river-mussel of that country (*Dipsas plicatus*). These little figures, made of tin, are carefully inserted so as not to injure the animal, which is then returned to the water and left for some months or a year. When again dredged up and opened, the figures are found to be entirely coated over with the pearly material and slightly attached thereby to the inner surface of the valve; they may then be easily removed and used for ornaments or charms (plate III). The Chinese also sometimes insert strings of small beads, which become apparently pearls, and carry out this same method by other ingenious devices.

In a shell in the Lea collection of *Unionidæ*, which has been presented to the United States National Museum, an oval piece of white wax, flat on the lower side and rounded on the upper, which had been inserted in the valve near the hinge, is entirely coated with a beautiful pink nacre. It has been broken out of the shell, the pearly nacre of the lower or flat side remaining in the shell, whereas the dome-shaped piece retains the coating.

At the International Fisheries Exhibition, held in Berlin during 1880, there were shown the results of experiments undertaken in Germany toward the production of artificial pearls from Unios, in a manner similar to that practiced by the Chinese. Flat tin figures, usually of fish, were introduced between the mantle and the shell. Similar experiments were conducted in the Royal Saxon pearl fisheries. Either small foreign bodies were introduced into the mantle, in order to form the nucleus for the free pearl formation, or the Chinese method of inserting such bodies between the mantle and the shell was followed. From the second method successful results were shown. The foreign bodies that had been introduced—poor pearls from other mussels, pieces of grain, or china buttons—were entirely covered with nacreous substance. The shape of these objects makes it impossible for the mantle to fit closely around

## EARLY HISTORY OF UNIO PEARLS IN NORTH AMERICA.

The history of Unio pearls in North America may be reviewed briefly as follows, from the dim, prehistoric past, through the period of discovery and exploration, and finally in recent and present developments:

Examinations of some of the mounds of the Mississippi Valley, especially at certain points in Ohio, have revealed the fact that the forgotten race that erected these remarkable structures gathered and used the fresh-water pearls to an extent that is to us astonishing. On the hearths of some of these mounds in Ohio the pearls have been found, not by hundreds, but by thousands, and even by bushels, now of course, damaged and half-decomposed by centuries of burial and by the heat of sacrificial fires. How such enormous stores of them were obtained is a problem not easy to solve, for all the pearls that have been gathered in the recent years of search and excitement would not approach in number those found in any one of several such mounds.

There would seem to be a strong presumption that these ancient people must have used the Unios largely for food, as we know that the later Indian tribes did. They naturally were thus led to the finding of pearls, and accumulated large stores of them in the course of time. The ancient tribes of Brazil have left shell-heaps along rivers tributary to the Amazon, composed of fresh-water shells of that region (*Hyria* and *Castalia*); and though no such stores of pearls have been found, yet the shells themselves have been much employed as ornaments among these people.

Passing on to the period of European discovery and exploration, we find in the early records interesting accounts of the possession of pearls by the Indian tribes of this country, which they had evidently obtained, largely, if not wholly, from the fresh-water shells of our rivers and lakes. The Spanish explorers who accompanied DeSoto in his memorable expedition from Florida to the Mississippi, in 1540, give many remarkable accounts of the pearl treasures seen and procured among the natives with whom they came in contact in their extensive wanderings through the region of the Gulf States, and a hundred years later some of the English colonists made references of a similar kind in their accounts of the more northern tribes.

The whole subject of Unio pearls, however, remained almost untouched by the white settlers and colonists until the middle of the present century. In 1857 the first important pearl discovery was made, near Paterson, N. J.; and since then, at intervals of some years, valuable discoveries have been made in other parts of the country, followed in each case by a widespread popular excitement, or "pearl fever," which has resulted in the almost complete destruction of the shells over considerable areas. When the streams have been "cleaned out," and a good many fine pearls procured and sold, and no more are attainable, the excitement subsides, and the shells are again enabled to grow undisturbed, and in some degree replenish the streams. But of late years the pearl-hunting has extended more widely, and the shells are being rapidly reduced; and unless improved methods are adopted for their protection the fresh-water pearls of North America will, ere long, become a thing of the past.

Taking up the several historical aspects more in detail, we may review, first, the evidence as to prehistoric use of North American fresh-water pearls and pearl shells, illustrating it by some references to the habits of modern tribes in other regions.

Many years ago, perforated pearls were found by Dr. Edwin H. Davis[1] on the earths of five distinct groups of mounds in Ohio, and sometimes in such abundance hat they could be gathered by the hundred. They were generally of irregular form, ıostly pear-shaped, though perfectly round ones were also found among them. The maller specimens measured about one fourth of an inch in diameter, but the largest ıad a diameter of three-fourths of an inch.

According to this same authority, the pearl-bearing shells occurring in the rivers f the region whose antiquities are described are not in such abundance that they ould have furnished the amount discovered in the tumuli; and the pearls of these uviatile shells, moreover, are said to be far inferior in size to those recovered from he altars. It was erroneously thought that the latter were derived from the coast of he Atlantic and of the Gulf of Mexico.

In this connection some curious facts are mentioned by the late Dr. E. G. Squier[2] egarding the use of pearls by the Ohio Mound-builders for ornamenting articles of arved stone. He describes a number of objects, chiefly pipes, made in the form of eads of animals and birds, carefully and accurately carved from what he terms por- hyry, with the eyes represented by small pearls, decomposed or calcined when found, ut in some instances retaining their places. Another similar object was a small uman head, the face apparently tattooed, also carved out of dark porphyry, with a ow of 15 holes, close together, forming a fillet across the top of the forehead. When ound, "these holes were filled with small calcined pearls, originally constituting a rilliant circlet, contrasting in a striking manner with the dark stone in which they ere inserted." He compares this little object with one described by Humboldt Researches, vol. I, p. 43) under the title of "Statue of an Aztec Priestess," which ears a similar line of sculptured beads or pearls across the forehead.

Mr. Squier refers to the great abundance of pearls found upon the hearths of ome of the Ohio mounds even at that early stage of exploration. He thinks that ieir number and size are too great to attribute them to the Unios, and dwells upon ie marine shells of the Gulf coast, that are found also in the mounds, and beads ade therefrom, as likewise alligators' teeth, tertiary fossils of the South, etc., as ointing to extensive traffic and intercourse with the shores of the Mexican Gulf. o doubt there was much of such intercourse, but most of the pearls found in Ohio re probably from the inland waters.

Pearls have subsequently been found in great numbers in the tumuli of the Scioto id Miami valleys, in Ohio, by Prof. F. W. Putnam, of the Peabody Museum, Cam- ridge, Mass., and Mr. Warren K. Moorehead, of Xenia, Ohio, who made extensive xplorations in these mounds, some of the results of which were shown at the Colum- ian Exposition at Chicago. The former had investigated particularly the Turner roup of mounds in the Little Miami Valley, the latter the Hopewell group in Ross ounty near Chillicothe, on the North Fork of Paint Creek.

In the Anthropological Building at Chicago was shown the great "find" of pearls ade by Mr. Moorehead in the Effigy mound of the Hopewell group. Here more ian a gallon of pearls was obtained, with two skeletons. They ranged from the size f a small millet seed to a diameter of two-thirds of an inch, or even more. In shape ey were usually irregular, though many were round or nearly so; but the absence

[1] Ancient Monuments of the Mississippi Valley, Squier & Davis, Washington, 1848, p. 252.
[2] Observations on the Aboriginal Monuments of the Mississippi Valley, Trans. of the Amer. Ethnological Society, New York, vol. II, 1847.

of the elongated and hinge pearls is remarkable. All had been drilled with holes varying from 1 to fully 3 millimeters in diameter, but generally the larger size, made with a heated copper wire in the manner described by early travelers as common among the Indians. This drilling was undoubtedly for the purpose of attaching them to clothing or belts, as shown by the fact that 400 or 500 had been originally sewed upon a rough cloth shirt extending from the waist to the knees of a skeleton. Copper plates on the hips had preserved traces of the cloth, and several dozen beads were found with cloth fiber still extending through the perforation. Pearls were usually placed at the wrists, on the ankles, around the neck, or in the mouth. In the Porter mounds at Frankfort, Ross County, several hundred were on copper plates. Nearly all, however, are found loose, although some are imbedded in a hard, rock-like mass of clay, cemented either by a calcareous solution from the weathering of the pearls or by an iron oxide produced by the decomposition of the meteoric iron ornaments that were found in such quantities in the Hopewell group of mounds. These, like all the pearls found in mounds in the Ohio and adjacent valleys, were undoubtedly from the Unios, which were evidently very plentiful at the time. Very few of the pearls retained any of the original orient, although it is possible that by peeling them some good unaltered pearl surfaces could be obtained; but it is more likely that either heat or burial in the ground, where they have undoubtedly lain for centuries, has destroyed them by infiltration of surface waters through the earth in which they were imbedded.

In the explorations which Mr. Moorehead conducted he found over forty bears' teeth in which pearls had been set, lying near skeletons. The settings were in the side or near the base (root) of the tooth. Skeletons accompanied by a large number of pearls always have other relics associated with them, such as native copper articles, mica, obsidian, galena, hematite, ocean shells, bad-land fossils, and other foreign objects. This fact would indicate clearly that the remains thus distinguished must have been those of prominent persons.

At a mound in the Little Miami Valley Professor F. W. Putnam and Dr. Charles L. Metz procured more than 60,000 pearls, nearly two bushels, drilled and undrilled, undoubtedly of Unio origin, all of them, however, decayed or much altered and of no commercial value. In 1884 these scientists examined the Marriott mound and found nearly 100 Unio shells; among other objects of interest were six canine teeth of bears perforated by a lateral hole near the edge at the point of greatest curvature of the root, and by passing a cord through this the tooth could be fastened to any object or worn as an ornament. Two of the teeth had a hole bored through near the end of the root on the side opposite the lateral perforation, and the hole countersunk in order to receive a large spherical pearl about three-eighths of an inch in diameter. When the teeth were found the pearls were in place, although chalky from decay. Over 250 pearl beads were found, concerning which they say:

> The pearl beads found in the several positions mentioned are natural pearls, probably obtained from the several species of Unios in the Ohio rivers. In size they vary from one tenth inch to one-half inch in diameter, and many are spherical. They are neatly drilled, and the larger from opposite sides. These pearls are now chalky, and crumble on handling, but when fresh they would have formed brilliant necklaces and pendants.—(18 Rept. Peabody Museum, p. 449, 1886.)

At the Turner group, in the Little Miami Valley, Professor Putnam, exploring for the Peabody Museum, secured half a bushel, nearly every one blackened by heat, some cracked, and all impaired in luster. Mr. Moorehead took from two hearths upward of 100,000 pearls.

In an altar or "hearth" of the Effigy mound were found a number of bears' teeth and several quarts of pearls, many of which had several successive layers flaked off. Some of these pearls measured two-thirds of an inch in diameter. In this remarkable altar were found hundreds of obsidian knives and spears of exquisite workmanship, measuring from a few inches up to 8 inches in length. With these were several hundred earrings made of native copper coated with meteoric iron.

From their manner of occurrence in connection with the skeletons, the archæologist is led to see that the use of pearls, although so many are found, was confined to a few individuals. A remarkable fact in this connection is that pearls have never been found in isolated mounds nor out of the great mound groups. The hill mounds, the villages of the small streams, and the tumuli of northern Ohio have yielded none. They seem to have been used by the more cultured tribes, and are an evidence of extensive trade and barter.

It is of interest to archæologists to note, further, that pearls are not found in any quantity outside of the Miami and Scioto valleys, and that they were deposited with the remains of persons held in especial distinction, while the enormous numbers found indicate that the yield of Unio pearls must have been far greater in the remote past than it has been at any time since the whites have occupied the country.

From Taylor's mound, Oregonia, Warren County, Ohio, there were four Unio shells in which a hole two-thirds of an inch in diameter had been drilled, either for the purpose of extracting a piece of the shell to make a bead from, or else to allow the shell to be used as an ornament. From this same mound were shown decorated disks made of Unio shells and a long Unio from which the corner nearest the lip had been ground down or cut off, to adapt it for use as a scraper or a tool of some kind.

The South American exhibits at the Columbian Exposition at Chicago presented many interesting uses of pearly shells, both for inlaying and in various forms of personal adornment. Both these modes of application seem to have been carried very far among some of the native tribes of this continent.

In the Amazon Basin the Unio family is well developed, but is largely represented by two genera not found elsewhere—*Castalia* and *Hyria*. These are characteristic South American types, differing from the Unios and Anodons of North America and the Old World, but equally suitable for ornamental uses from their pearly character. Probably many of the objects here described were made from these shells.

In the Paraguay collection were a number of necklaces made of oblong squares of Unio shell, and connected by means of a fiber drawn through two drilled holes at the upper end, while the lower ends are decorated with three small circular drillings which do not entirely perforate the shell. Another necklace consisted of small joints of hollow reed or bamboo, about an inch in length, between which were blue glass beads, and pendent from each of these a small brilliant Unio shell, pure white, with a slight iridescence, and remarkably beautiful. Still another necklace was made entirely of Unio shells, not very iridescent, with the dark-brown epidermis remaining on the exterior. Internally the drilling was either near one of the ends or toward the center of the shell. These were strung by thin vegetable fiber, so as to hang pendent about 3 inches from the fiber necklace, and were evidently intended to serve for a rattle or noise-producing ornament. In the same exhibit were a number of pendants, consisting of small pieces or large sections of Unio shells, beautifully iridescent, varying from oval to disk shape, and from 1 to 4 inches long. In another necklace Unios were strung indiscriminately with hoofs of some small animal.

The use of shells as ornaments is very pronounced among these people. In addition to those mentioned, bullas and land shells were strung in a similar manner. These were white, gray, yellow, frequently with pink-tinted tips. An interesting necklace consisted of operculums, 2 inches in length, of some large shell, attached by a fiber and decorated with yellow feathers.

From Peru life size models of the Zaperos and Jiveros Indians, residing on the Montaña of Peru, were shown fully attired with their ornaments. These tribes decorate their head-dresses, shoulder-bands, and breasts with a profusion of circular, diamond-shaped, and pear-shaped pieces of a brilliant Anodon shell. These they arrange to form stars and other patterns by sewing a number of them to the fabric, generally by means of perforations, and they frequently have them swinging as pendants from the dress. They also use small Unio shells, the wing-cases of beetles, white and red dried seeds, teeth of animals, etc.

Passing to the historical accounts of the early explorers of the New World, we find that Columbus himself and all the Spanish discoverers were attracted and impressed by the frequent and abundant possession of pearls among the natives. These pearls among the West Indian peoples and the coast tribes were probably from the marine pearl oyster which occurs to some extent along the shores of the Caribbean Sea. On the mainland of North America, however, it seems clear that the pearls found by DeSoto and his party all through the present Southern States must have come largely from the Unios of the adjacent lakes and streams, like those possessed by the prehistoric Mound-builders before.

Omitting for the present many interesting accounts of pearl treasures observed in the West Indies, and by Balboa and others on or near the Pacific shores of Central America and the Isthmus—which last relate to the true marine pearl oyster—we may pass to the accounts of De Soto's expedition, and the pearls found and seen throughout the whole region from Florida to upper Georgia, Alabama, and Tennessee.

When the king of Spain made Hernando DeSoto governor of Cuba and conqueror of Florida, with the title of Adelantado, his concession provided that one-fifth of all the gold and silver, precious stones, and pearls won in battle, on entering towns, or obtained by barter with the Indians, be reserved to the Crown. It was further stipulated that the gold and silver, gems, pearls, and other treasures which might be found and taken, as well in the graves, sepulchers, ocues, or temples of the Indians as in other places where they were accustomed to offer sacrifices to idols, or in other concealed religious precincts or buried houses, or in any other public place "should be equally divided between the king and the party making the discovery."[1] It is evident that among the valuable trophies of this expedition precious pearls were confidently anticipated; and that the Spaniards were not disappointed in this expectation the early narratives abundantly testify. These establish beyond all controversy that pearls were used as ornaments among the Indians of Florida and the South.

It is related how, near the Bay of Espiritu Santo (now Tampa Bay), in Florida, the followers of DeSoto came upon the town of an Indian chief called Ucita. His house stood near the beach, and at the other end of the town was a temple, on the top of which perched a wooden fowl with gilded eyes. Within these eyes were pearls such as the Indians greatly valued, piercing them for beads and stringing them to wear about their necks and wrists. When the Indian queen welcomed the Spanish adventurer to the hospitalities of the Cutifachiqui she drew from over her head a long string

[1] Antiquities of the Southern Indians, by Charles C. Jones (New York, 1873), p. 467.

of pearls, and, throwing it around his neck, exchanged with him gracious words of friendship and courtesy. Observing that the Christians valued these pearls, the cacica told the governor that if he would order the search of some sepulchers in the village he would find many pearls, and if he chose to send to the sepulchers in the uninhabited towns he might load all his horses with them. The Spaniards did examine and rifle of their contents the sepulchers in Cutifachiqui, and upon the authority of the Knight of Elvas obtained from them 350 pounds' weight of pearls, some of which were formed after the similitude of babies and birds (baroques). If the truth were known, or if an Indian had written this account, we should probably find that DeSoto and his companions, in their eager quest for treasures, violated the graves without permission and plundered the receptacles wherein were gathered the most costly possessions of the natives. As a proof that the Indians did not willingly part with these ornaments, but suffered pillage through fear of these strange and wanton men, we are informed that when the cacica, whom DeSoto compelled to accompany him with the intention of taking her to Guaxule, which was the farthest limit of her territory, succeeded in making her escape, she carried back with her a cane box filled with unbored pearls, the most precious of all her jewels.

Luys Hernandez de Biedma says that the governor, while at this town, opened a "mosque" in which were interred the chief personages of that country.

> From it we took a quantity of pearls of the weight of as many as 6½ or 7 arrobas, though they were injured from lying in the earth and in the adipose substance of the dead.

In the estimate of the relator, one of the saddest losses encountered by the expedition in the bloody affair at Mauilla was the destruction of the pearls which the Spaniards had been sedulously collecting during their wanderings in this strange land.

The most minute and interesting description of the manner in which the Indians obtained pearls and converted them into beads is furnished by Garcilasso Inca de la Vega. While De Soto was in the town of Ichiaha, which was probably located at or near the confluence of the Etowah and Oostanaula rivers, possibly on the very spot now occupied by the city of Rome, Georgia, the following circumstance occurred:

> The cacique came one day to the governor, bringing him a present of a string of pearls 5 feet in length. These pearls were as large as filberts, and had they not been bored by means of fire, which had discolored them, would have been of immense value. De Soto thankfully received them, and in return presented the Indian chief with pieces of velvet and cloth of various colors and other Spanish trifles held in much esteem by the natives. In reply to the demand of De Soto, the cacique stated that the pearls had been obtained in the neighborhood. He further told him that in the sepulcher of his ancestors was amassed a prodigious quantity, of which the Spaniards were welcome to carry away as many as they pleased. The Adelantado thanked him for his good will, but replied that, much as he wished for pearls, he never would insult the sanctuaries of the dead to obtain them, adding that he only accepted the string from the chieftain's hands.
>
> De Soto having expressed a curiosity to see the manner of extracting pearls from the shells, the cacique instantly dispatched 40 canoes to fish for oysters during the night. At an early hour next morning a quantity of wood was gathered and piled upon the river bank, and being set on fire was speedily reduced to glowing embers. As soon as the canoes arrived the oysters were laid upon the hot coals. They quickly opened with the heat, and from some of the first thus opened the Indians obtained 10 or 12 pearls as large as peas, which they brought to the governor and the cacique, who were standing together looking on. They were of a fine quality, but somewhat discolored by the fire and smoke. The Indians were apt also to further injure pearls thus obtained by boring them with a heated copper instrument.
>
> De Soto, having gratified his curiosity, returned to his quarters to partake of his morning meal. While thus engaged a soldier entered with a large pearl in his hand. He had stewed some oysters,

and in eating them felt the pearl between his teeth. Not having been injured by fire or smoke, it retained its beautiful whiteness, and was so large and perfect in its form that several Spaniards, who pretended to be skilled in those matters, declared it would be worth 400 ducats. The soldier would have given it to the governor to present to his wife, Dona Isabel de Bobadilla, but De Soto declined the generous offer, advising him to preserve it until he should arrive at Havana, when he could purchase horses and other necessaries with it; moreover, as a reward for his liberality, De Soto insisted upon paying the fifth of the value due the Crown.[1]

During the course of the weary march of the expedition through the mountains of upper Georgia, the following circumstance is related by the same historian:

A foot-soldier, calling to a horseman who was his friend, drew forth from his wallet a linen bag in which were 6 pounds of pearls, probably filched from one of the Indian sepulchers. These he offered as a gift to his comrade, being heartily tired of carrying them on his back, though he had a pair of broad shoulders capable of bearing the burden of a mule. The horseman refused to accept so thoughtless an offer. "Keep them yourself," said he, "you have most need of them. The governor intends shortly to send messengers to Havana, when you can forward these presents and have them sold, and obtain three or four horses with the proceeds, so that you need no longer go on foot." Juan Terron was piqued at having his offer refused. "Well," said he, "if you will not have them, I swear I will not carry them, and they shall remain here." So saying, he untied the bag, and whirling it around as if he were sowing seed, scattered the pearls in all directions among the thickets and herbage. Then putting up his bag in his wallet, as if it was more valuable than the pearls, he marched on, leaving his comrades and other bystanders astonished at his folly. The soldiers made a hasty search for the scattered pearls and recovered thirty of them. When they beheld their great size and beauty, none of them being bored or discolored, they lamented that so many of them had been lost, for the whole would have sold in Spain for more than 6,000 ducats. This egregious folly gave rise to a common proverb in the army, "There are no pearls for Juan Terron." The poor fellow himself became an object of constant jest and ridicule, until at last, made sensible of his absurd conduct, he implored them never to banter him further on the subject.[2]

Fontaneda states that at the place where Lucas Vasquez went seed pearls were found in certain conchs, and that between Havalachi and Olagale is a river called by the Indians Guasacaesqui, which means, in the Spanish language, Rio de Canas (river of canes), which is an arm of the sea; and along the adjacent coast pearls are procured from certain oysters and conchs. These are carried to all the provinces and villages of Florida, but principally to Tocobaja, the nearest town. The Indians of the town of Abalachi asserted that the Spaniards hanged their cacique because he would not give them a string of large pearls which he wore around his neck, the middle pearl of which was as big as the egg of a turtle-dove. Ribault frequently alludes to the possession of pearls by the natives of Florida, and on one occasion saw the goodliest man of a company of Indians with a collar of gold and silver about his neck, from which depended a pearl "as large as an acorn, at the least."[3] A present of pearls from the cacique to the conquerors was an earnest token of consideration and the most acceptable pledge of friendship that he could offer.

According to Albert J. Pickett, the oyster alluded to by Garcilasso was identical with the mussel so common in all the rivers of Alabama He says:

Heaps of mussel shells are now to be seen on our river banks wherever Indians used to live. They were much used by the ancient Indians for some purpose, and old warriors have informed me that their ancestors once used the shells to temper the clay with which they made their vessels. But as thousands of the shells lie banked up, some deep in the ground, we may also suppose that the

[1] The foregoing is taken from Theodore Irving's Conquest of Florida under Hernando DeSoto (London, 1835), vol. 2, p. 14, and is from Pierre Richelet's translation, made in 1831. De la Vega's entire work, translated from the same source, appears in the History of Hernando DeSoto and Florida, by Barnard Shipp (Philadelphia, 1881).

[2] Conquest of Florida under Hernando DeSoto, by Theodore Irving (London, 1835), vol. 2, p. 7.

[3] The Whole and True Discovery of Terra Florida, by Thomas Hackett (London, 1563).

Indians in De Soto's time, everywhere in Alabama, obtained pearls from them. There can be no doubt about the quantity of pearls found in this State and Georgia in 1540, but they were of a coarser and more valueless kind than the Spaniards supposed. The Indians used to perforate them with a heated copper spindle and string them around their necks and arms like beads.

David Ingram, during the "Land Travels" of himself and others in the year 1568–1569, from the Rio de Minas in the Gulf of Mexico to Cape Breton in Acadia, made the following observations:

There is in some of those Countreys great abundance of Pearle, for in every cottage he founde Pearle, in some howse a quarte, in some a pottell, in some a pecke, more or lesse, where he did see some as great as an acorn, and Richard Browne, one of his companions, found one of these great pearls in one of their canoes, or Boates, Wch Pearle he gaue to Mouns Champaine, whoe toke them aboarde his Shippe, and brought them to Newhaven in ffraunce.

The English were quick to note the presence of pearls in America, being already acquainted with those found in the rivers of Scotland and Ireland; and hence we have repeated references to them from early English travelers and colonists.

A member of the expedition of Sir Walter Raleigh collected from the natives of Virginia 5,000 pearls, "of which number he chose so many as made a fayre chaine, which for their likeness and uniformity in roundnesse, orientnesse and pidenesse of many excellent colors, with equalitie in greatness, were very fayre and rare."[1]

In the plates illustrative of the "Admiranda Narratio" and the "Brevis Narratio," the natives both of Virginia and Florida are represented in the possession of numerous strings of pearls of large size; and in his description of the "treasure of riches" of the Virginia Indians, Robert Bevery says:

They likewise have some pearls amongst them, and formerly had many more, but where they got them is uncertain, except they found them in the oyster banks which are frequent in this country.[2]

Wilson asserts that he saw pearls "bigger than Rouncival pease," and perfectly round, taken from oysters found on the Carolina coast.[3]

Father Louis Hennepin assures us that the Indians along the Mississippi wore bracelets and earrings of fine pearls, which they spoiled, having nothing to bore them with but fire. He adds:

They gave us to understand that they received them in exchange for their calumets from nations inhabiting the coast of the great lake to the southward, which I take to be the Gulph of Florida.

Sufficient historical evidence has been given to show that pearls were in general use among the southern Indians; that the choicest of them were the prized ornaments of the prominent personages of the tribes; that the fluviatile mussels were collected and opened for the purpose of procuring them; that the marine shells of the Atlantic, the Gulf of Mexico, and the Pacific, yielded tribute to the labor, skill, and taste of numerous pearl-divers, and that these pearls were found, not only in the possession of the living, but also in large quantities in the graves of chieftains and the sepulchers of the undistinguished dead.

Doubtless, however, the accounts that have reached us from the historians of these expeditions and voyages are somewhat extravagant with regard to the quality, quantity, and size of the pearls in the possession of the natives. From the interviews between the Europeans and the latter, it appears that the Indians obtained their pearls both from marine shells and from fresh-water mussels. Some of the true oysters of Georgia and Florida are margaritiferous, and many of them contain seed

[1] A Briefe and True Report of the New Found Land of Virginia (Frankfort on the Main, 1590) p. 11.
[2] Documents connected with the History of South Carolina, edited by Plowden Charles Jennett Weston (London, 1856), p. 8.
[3] Transactions of the Philosophic Society for 1693.

pearls. Specimens symmetrical in shape, as large as pepper-corns, and not wanting in beauty, have been observed by Col. Charles C. Jones, who says:

> Some were quite big enough to have been perforated in the rude fashion practiced by the Indians. They were, however, of a milky color and opaque. Neither in size nor quality did they answer the description spoken of in the Spanish narratives.[1]

The fluviatile mussels contributed more freely than any others to the treasures of these early people. At various points along the southern rivers relic beds are found, composed of the fresh-water shells native to the streams.

Kjoekkenmoeddings on the St. Johns River, Florida, consisting of river shells, were examined and described by Prof. Jeffries Wyman. He saw similar accumulations on the banks of the Concord River in Massachusetts, and was informed by eye-witnesses that they are numerous in California.[2] The inland lakes of Florida, also, and even some ponds in middle Georgia and Alabama, exhibit along their banks similar ancient refuse piles where lacustrine shells abound. These heaps are common in the South, and several of them on the banks of the Savannah River, above Augusta, are fully described by Charles C. Jones.[3] He says:

> In these relic beds no two parts of the same shell are, as a general rule, found in juxtaposition. The hinge is broken, and the valves of the shell, after having been artificially torn asunder, seem to have been carelessly cast aside and allowed to accumulate.

In order to ascertain the precise varieties of shells from which the southern Indians obtained their pearls, Mr. Jones invited an expression of opinion from the following scientists, whose pursuits rendered them familiar with the conchology of the United States. They throw considerable light upon this inquiry.

Dr. William Stimpson, of the Chicago Academy of Sciences, considered the statements of the early Spanish historians with regard to the size of the pearls (as large as filberts) exaggerated. He says:

> The pearls of the *Avicula*, our only margaritiferous marine genus, are very small, and those of the oyster valueless. The Indians must have obtained their pearls from the fresh-water bivalves (*Unio* and *Anodon*) which abound in the rivers of Georgia, etc. These are usually small, but in very rare instances examples have occurred reaching in diameter one-third of an inch.

Prof. Joseph LeConte writes:

> Most of the fresh-water mussels contain small pearls now and then. By far the best and largest number I have seen were taken from the *Anodon gibbosa* (Lea), a large and beautiful shell abundant in the swamps of Liberty County, Ga., at least in Bulltown and Altamaha swamps. Some of the pearls taken from this species are as large as swan shot. Of the salt-water shells, I know not if any produce pearls except the oyster (*Ostrea virginica*). Pearls of small size are sometimes found in them.

Prof. William S. Jones, of the University of Georgia, says that he has seen small pearls in many of the Unios found in southern Georgia.

Prof. Jeffries Wyman, after a careful and extensive series of excavations in the shell-heaps of Florida, failed to find a single pearl. He remarks:

> It is hardly probable that the Spaniards could have been mistaken as to the fact of the ornaments of the Indians being pearls; but in view of their frequent exaggerations I am almost compelled to the belief that there was some mistake, and possibly they may not have distinguished between the pearls and the shell beads, some of which would correspond with the size and shape of the pearls mentioned by the Spaniards.

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[1] Antiquities of the Southern Indians (New York, 1873), p. 481.
[2] Cf. Fresh-Water Shell Heaps of the St. Johns River, East Florida (Salem, Mass., 1868), p. 6.
[3] Antiquities of the Southern Indians (New York, 1873), p. 483; also Monumental Remains of Georgia (Savannah, 1861), p. 14.

Prof. Joseph Jones, whose investigations throw much valuable light upon the contents of the ancient tumuli of Tennessee, says:

I do not remember finding a genuine pearl in the many mounds which I have opened in the valleys of the Tennessee, the Cumberland, the Harpeth, and elsewhere. Many of the pearls described by the Spaniards were probably little else than polished beads cut out of large sea shells and from the thicker portions of fresh-water mussels, and prepared so as to resemble pearls. I have examined thousands, and all present a laminated structure, as if carved out of thick shells and sea conchs.

Charles M. Wheatley was confident that there were "splendid pearls in southern Unios," and instances the *Unio blandingianus* and the large old *Unio buddianus* (*buckleyi*) from Lakes George and Monroe in Florida as pearl-bearing. He says:

In Georgia the large, thick shells of the Chattahoochee, such as the *Unio elliotti*, would be most likely to contain fine ones, but there is no positive rule, as an injured shell of any species will doubtless afford some, irregular in most cases and of no value, but in some instances worth from $50 to $100.

He also mentions that he has received from the Tennessee River, in Alabama, fine round pearls, both white and rose-colored.

John G. Anthony writes:

I never have collected in Florida and but little in Georgia, but what I can say about Ohio I presume will hold good in other States, that the *Unios* of various species furnish them tolerably abundantly there. They are not confined to any particular species, but are generally found in the thicker and more ponderous shells, though even the thinner shells often have small ones, especially such as are found in canals, ponds, and places which seem to be not so healthy for the animal on account of stagnant water. I recollect taking over twenty small ones out of the mantle of one specimen of *Unio fragilis*—*U. gracilis* (Barnes)—which I found in the Miami Canal; and almost every old shell there had more or fewer pearls in it. *U. torsus* (Raf.), *U. orbiculatus* (Hildreth), *U. costatus* (Raf.), and *U. undulatus* (Barnes) also produce them in Ohio. I have seen about half a pint of beautiful pearls, regularly formed and pea size, which were taken in one season and in one neighborhood; so you may judge of their frequency, though, as I hinted before, it is probable that a kind of disease caused by impure water may govern their production somewhat. No doubt the Southern waters are given to making pearls, as well as Ohio streams. I have seen protuberances of the pearl character in southern shells, and have no doubt that one collecting them with the animal in them would find pearls. I particularly recollect *Unio globulus* (Say) and *U. mortoni* (Conrad), both Louisiana species, as having these protuberances in their nacreous matter. Georgia *Unios* are generally too thin to produce any excess of pearly matter and form pearls, but the Louisiana shells from Bayou Teche which I have seen have a remarkably pearly nacre, quite thick, reminding one very much of the marine shell *Trigonia* as to nacre. No doubt the bayous, which have in general no current at all, would make first-rate places for pearl breeding.

Dr. Charles Rau[1] writes:

I learned from Dr. Samuel G. Brinton, who was surgeon of the Army of the Cumberland during the civil war, that mussels of the Tennessee River were occasionally eaten "as a change" by the soldiers of that corps, and pronounced no bad article of diet. Shells of the *Unio* are sometimes found in Indian graves, where they had been deposited with the dead to serve as food during the journey to the land of spirits.

Dr. Brinton saw on the Tennessee River and its tributaries numerous shell-heaps consisting almost exclusively of the *U. virginianus* (Lamarck). In every instance he found shell-heaps close to the water-courses on rich alluvial bottom lands. He says:

The mollusks had evidently been opened by placing them on a fire. The Tennessee mussel is margaritiferous, and there is no doubt but that it was from this species that the early tribes obtained the hoards of pearls which the historian of DeSoto's exploration estimated by the bushel, and which were so much prized as ornaments.[2]

[1] Ancient Aboriginal Trade in North America, Report of the Smithsonian Institution for 1872, p. 38 of the author's reprint.

[2] See Artificial Shell Deposits in the United States, in the Report of the Smithsonian Institution for 1866, p. 357.

A source has recently been pointed out whence small pearls, and perhaps some fine ones, could have been obtained in considerable quantities by the Indians of Florida. In the Unios of some of the fresh-water lakes of that State there have been found large numbers of pearls, most of them small, but many large enough to be perforated and worn as beads. From one Unio there were taken 84 seed pearls; from another 50, from a third 20, and from several 10 or 12 each. The examinations were chiefly confined to Lake Griffin and its vicinity. It is said that on an island in Lake Okeechobee are the remains of an old pearl-fishery, and it is proposed to open the shells of this lake, which are large, in hopes of finding pearls of superior size and quality.

The use of pearls as ornaments by the southern Indians, and the quantities of shells opened by them in various localities, make it seem strange that pearls are not more frequently met with in the relic beds and sepulchral tumuli of that region; but after exploring many shell and earth mounds, Col. Charles C. Jones failed, except in a few instances, to find any.[1] A few were obtained in the extensive relic bed before alluded to, on the Savannah River above Augusta, the largest being four-tenths of an inch in diameter, but all of them blackened by fire. Many of the smaller mounds on the coast of Georgia do not contain pearls, because at the period of their construction the custom of burning the dead appears to have prevailed, hence it may be that the pearls were either immediately consumed or so seriously injured as to crumble out of sight. This absence of pearls tends somewhat to confirm the opinion that beads and ornaments made from the thicker portions of shells, that were carved, perforated, and brilliant with their primal covering, were regarded by the imaginative Spaniards as pearls. More minute investigation, however, will doubtless reveal the existence of pearls in localities where the pearl-bearing shells were collected. Perforated pearls have been found in an ancient burying-ground located near the bank of the Ogeechee River, in Bryan County, Ga.; and many years ago, after a heavy freshet on the Oconee River, which laid bare many Indian graves in the neighborhood of the large mounds on Poullain's plantation, fully a hundred pearls of considerable size were gathered.

It seems probable that what were regarded as pearls by the early Spanish voyagers were, to a large extent, really such, although it is well known that shell beads have been found in mounds in connection with pearls. But the numbers found in Ohio mounds by Prof. Frederick W. Putnam, and by others, leave no room for doubt in this matter. That the Indians of the South also had these pearls, both drilled and undrilled, is beyond question. Notwithstanding the intercourse existing between remote Indian tribes, as shown by many authorities, and the fact that Pacific coast shells have been carried to Arizona, and that clam shells have been found in Zuñi cities by Lieut. Frank H. Cushing, it is likely that these pearls came, not from the pearl oysters of the Pacific coast, but from the marine shells of the Atlantic coast and the fresh-water shells of the eastern part of the continent. It is very probable that the Indians opened the shells to secure the animal as an article of food; that the shells of some varieties, such as the common clam and conch, were made into wampum; and that the pearls found in the shells were used as ornaments, whether lusterless pearls from the common oyster or lustrous ones from the Unio.

For a considerable period, however, after the first explorations, the pearl resources of North America seem to have attracted little attention. The Indian race was contending with the whites for the possession of the country; it was a time of uncertainty and strife for both races; and not until the great waterways of the Mississippi Valley

[1] Antiquities of Southern Indians, p. 486.

ıd been won by the whites, the region occupied, and settled communities established, ɔ we again begin to find any indications of the search for pearls. For some two ɜnturies the Unios lived and multiplied in the rivers and streams, unmolested by ɨther the native tribes that had used them for food or the pioneers of the new race ıat had not yet learned of their hidden treasures.

Fresh-water pearls are found, as before stated, in various species of the Unios, ɜequently, according to Dr. Isaac Lea, in the common *Unio complanatus*, but also ı the following: *U. blandingianus*, *U. buddianus*, *U. costatus*, *U. elliotti*, *U. fragilis*, *U. globulus*, *U. gracilis*, *U. mortoni*, *U. nodosus*, *U. orbiculatus*, *U. ovatus*, *U. torsus*, *U. undulatus*, and *U. virginianus*, and doubtless to some extent in all the species. Not ne pearl in a hundred, however, is of good shape, and probably not more than one in hundred of these is really fine. Therefore, as the worth of a pearl depends on both ıster and form, the greater number obtained are of slight value. Rev. Horace C. Iovey, however, is credited with having found a pearl half an inch across in the shell f a *Unio ovatus*, near Cincinnati, Ohio.

Unio pearls have been sought since the settlement of this country, and the narra- ives of early voyagers abound with references to them. In an ancient catalogue[1] f the objects of natural history, made in 1749 by John Winthrop, F. R. S., the follow- ıg items are mentioned:

30. Unripe pearls which in time would have become (31).

31. Bright pearls which are produced in the same shells (30).

32. Some of the larger sea pearl shells which are often found in deeper waters three times as ırge and bear larger pearls.

N. B.—Almost all the lakes, ponds, and brooks contain a large fresh-water clam which also bears earls. The Indians say they have no pearls in them at certain seasons, but at the season when they row milky the pearls are digested in them, which causes their milkiness.

Dr. Samuel P. Hildreth writes:

Some of the fresh-water shells produce very fine pearls. I have one taken in the waters of the Iuskingum, from the shell known as the *Unio nodosus* of Barnes. It is a thick, tuberculated shell, ɜith the most rich and pearly nacre of any in the Western rivers. The specimen is perfect in form, eing plano-convex on one side and a full hemisphere on the opposite. It is nearly one-half inch in iameter across the plane face, and three-eighths inch through the transverse diameter, and of a very ich pearly luster. Set in a gold watch-key and surrounded by facets of jet it makes a beautiful ppearance, and is by far the largest and finest pearl I have ever seen. Several others have been ɔund, but none to be compared to this.[2]

Within recent years, however, the gathering of Unio pearls has attained to con- ıiderable importance, and economic problems have begun to arise that warrant and ɜven demand careful and detailed inquiry. These present aspects will be considered ɲ the following pages.

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[1] Am. J. Sci., I, vol. 47, p. 284, Jan. 1845.

[2] Am. J. Sci., I, vol. 25, p. 257, April 1834. Ten Days in Ohio, from the Diary of a Naturalist.

## THE PEARL FISHERIES OF THE UNITED STATES IN RECENT YEARS.

Although the gathering of pearls from the fresh-water shells of North America is a matter of comparatively recent date among the present inhabitants, it really goes back very far, as already indicated, into the unrecorded past. The first European explorers speak frequently of the number and beauty of the pearls in possession of the natives. Full references have been given previously to the striking accounts in connection with the great expedition of DeSoto from Florida through the present Gulf States to the Mississippi in 1540–41 and to the process of gathering the shells and opening them by heat, as shown to DeSoto, at his request, by a friendly chief. In the same way several early English travelers, from New England to Florida, refer to the Indians as having pearls. No particular attention, however, was given to the subject in the United States until about forty years ago. The natives had been dispossessed, and the white race, occupied with other interests and necessities, took little note of the hosts of fresh-water shells inhabiting the streams and lakes, and did not suspect their power of producing pearls.

In 1857 a pearl of fine luster, weighing 93 grains, was found at Notch Brook, near Paterson, N. J. It became known as the "Queen pearl," and was sold by Tiffany & Co. to the Empress Eugenie of France for $2,500. It is to-day worth four times that amount. The news of this sale created such an excitement that search for pearls was started throughout the country. The Unios at Notch Brook and elsewhere were gathered by the million and destroyed, often with little or no result. A large, round pearl weighing 400 grains, which would doubtless have been the finest pearl of modern times, was ruined by boiling to open the shell. Within one year pearls were sent to the New York market from nearly every State—in 1857 fully $15,000 worth. In 1858 it fell off to some $2,000; in 1859 about $2,000; in 1860 about $1,500; in 1860–1863 only $1,500. The excitement thus abated until about 1868, when there was a slight revival of interest, and many fine pearls were obtained from Little Miami River, Ohio.

Some of the finest American pearls that were next found came from near Waynesville, Ohio, $3,000 worth being collected in that vicinity during the pearl excitement of 1876. At that time Israel H. Harris, of Waynesville, began what has since become one of the finest and best-known collections of Unio pearls in this country, purchasing during many years every specimen of value that he could find in that part of the State. Among his pearls was one button-shaped on the back and weighing 38 grains; also several almost transparent pink ones, and an interesting specimen showing where a pearl had grown almost entirely through the Unio. His collection contained more than 2,000 pearls, weighing over 2,000 grains, and is in all probability the last collection that will be made from that district. It was exhibited in the jewelry department at the World's Fair held in Paris during 1889. Since 1880 pearls have come from comparatively new districts farther west and south, the supply from which is apparently increasing. At first but few were found, or rather few were looked for, west of Ohio, but gradually the line extended, and Kentucky, Tennessee, and Texas became the principal pearl-producing States, and some pearls were sent north from Florida.

A fine round, pink pearl of 30 grains was found in a Unio near St. John, New runswick, and now belongs to George Reynolts, of Toronto, Canada.

A few years later the interest extended to the Northwestern States. During the ummer of 1889 a quantity of magnificently colored pearls were found in the creeks nd rivers of Wisconsin, in Beloit, Rock County; Brodhead and Albany, Green ounty; Gratiot and Darlington, Lafayette County; Boscobel and Potosi, Grant ounty; Prairie du Chien and Lynxville, Crawford County. Of these pearls more nan $10,000 worth were sent to New York within three months, including one worth ıore than $500, and some among them were equal to any ever found for beauty and oloring. The colors were principally purplish-red, copper-red, and dark pink.

These discoveries led to immense activity in pearl-hunting through all the streams f the region, and in three or four seasons the shells were almost exterminated. In 890 it extended through other portions of Wisconsin, especially Calumet and Mani- owoc counties, and appeared also in Illinois, along the Mackinaw River and its ributary creeks, in McLean, Tazewell, and Woodford counties. The pearl fisheries f this State have produced at least $250,000 worth of pearls since 1889.

At the Columbian Exposition at Chicago in 1893 large and beautiful exhibits of earls, with a great variety of tints, were a notable feature in the Wisconsin State uilding and elsewhere, as previously noted.

The Northwestern pearl excitement subsided in a few seasons, as the others had one in turn before, by the exhaustion of the mussel beds and the consequent cessation f product. About every ten years or so a new wave of interest rises in connection ith fresh discoveries at some point where the shells have lain long undisturbed; it gain absorbs the attention and excites the imagination of the community around, and preads to other parts of the country; a fresh campaign of ignorant extermination is arried on for several summers, then the yield is exhausted, and there is nothing ıore but to leave nature to recuperate, if possible, and slowly to restore, in limited mount, the abundant life that has been destroyed.

The year 1897 witnessed a very widespread outbreak of the pearl mania, which xtended through large areas previously unaffected by it, reproducing in the most ıarked form all the manifestations before seen elsewhere—the excitement seizing upon he whole population; the abandonment of the ordinary forms of steady labor; the ocking of thousands to the rivers and streams to gather Unios; the wholesale estruction of the mussels until the locality was "cleaned out"; the extravagant leas of the value of the choice pearls obtained, and the disappointment of multitudes, ho imagined that every irregular nacreous concretion that they had found was a aluable treasure.

The chief center of this excitement was Arkansas, which had never known it efore. Thence it has extended west into the Indian Territory, and north into Mis- ouri, while Georgia and portions of Tennessee have been largely affected. The press otices of all these, often highly sensational, led to more or less activity in other parts f the country. As the season was well advanced before the subject attracted much ttention, it seems probable that the year 1898 will witness an unexampled furore of earl-hunting and that the shells will be practically exterminated for years to come hroughout much of the Mississippi Valley.

The portions of the State where the excitement has been most marked are the ollowing: (1) A region of small "lakes," i. e., expansions of streams, situated chiefly ı the southeastern part of White County, between White River, Cypress Bayou, and

the St. Louis and Iron Mountain Railroad; thence the excitement spread all up and down the valley of White River and its tributaries, passing into (2) the northeast portion of the State, along Black River, Cache River, and the great lake-like expanse of the St. Francis; (3) along the valley of the Arkansas and its tributaries from Little Rock eastward, and especially westward, to and into the Indian Territory, including mountain streams in Crawford County to the north and the valley of the Fourche to the south; (4) in the southern part of the State, along the Ouachita, Saline, and Dorcheat rivers. Without entering into minute details, these may be regarded as the chief pearl districts, but in various other parts operations were carried on to a greater or less degree.

In one respect these Arkansas discoveries were novel and peculiar. A large proportion of the best pearls were found not by opening the shells, but lying in the mud of the shores or at the bottom of shallow waters. Often, indeed, they were found in or upon the soil at some distance from streams or lakes. This peculiar occurrence is partly explained by the wide extension of the waters in flood times over the low regions of the State and by the shifting of streams and isolation of "cut-offs"; but the facts indicate further that under some circumstances, probably of agitation by floods and freshets, the loose pearls are lost or shaken out from the Unios. A local impression prevails that the mussels "shed" them at certain seasons. The fact that the pearls thus found were generally round and well formed; the aggregation in repeated instances of several or many near or together, and the non-occurrence of shells with them at these places—all point to the washing out of loose pearls from the Unios and their distribution by floods and freshets. So marked a feature, moreover, is their occurrence in the mud of the lakes and bayous, that it is even proposed to employ steam dredges to take up the mud and pass it through sieves or other similar devices in the expectation of finding therein the pearl product of many generations of shells.

Some of the more striking incidents of this mode of occurrence may be noted as follows: One of the latest announcements, in October, was that Mr. J. W. McIntosh, of Lonoke County, while digging post-holes in the bed of Cypress Bayou, 3 miles south of the town of Beebe, White County, found a number of pearls, some as large as a ".44-caliber Winchester ball," at a depth of 1½ feet below the surface. The pearls were lying together, but with no shells. Mr. McIntosh had refused a handsome offer for them, and was at last accounts still at work on his land. Another instance is that of a fisherman picking up a dozen pearls in a very short time by simply reaching over the edge of his boat as it lay by the shore of Walker Lake and taking them up from the bottom. Mr. T. J. Sharum, of Walnut Ridge, Lawrence County, which was the central trade-point for the pearl-hunting along Black and Cache rivers, emphasizes the fact that the pearls taken from the mussels were chiefly from young shells; hence it is believed that the old ones lose or "shed" them, and some propose to use a road-scraper next season to take up the mud and obtain the pearls that have accumulated in it. Many other accounts are given of pearls found on or in the soil, or in the mud, from the first main discovery in White County to various parts of the State.

Arkansas pearls were by no means unknown before, but they had not attracted any attention. On the contrary, they had been picked up for years by the country people and used merely as playthings and "luck-stones" among the children, with no idea of their value. Some, indeed, had been gathered and recognized, but the discoverers had kept quiet about them to avoid creating a "rush." Some twenty years ago

arls had been found by a party of men who were cutting cedar poles on White iver; in 1888 a brilliant pear-shaped pink pearl weighing 27 grains was found by a herman on White River and sold to Judge E. S. C. Lee, of Augusta, Ark., who had mounted as a scarf-pin and has worn it ever since; in 1895 a surveying party on hite River obtained pearls to the value (it is said) of $5,000; and country lads of e region have pearls in their possession up to 50 grains in weight, which they have icked up from time to time and used as marbles.

From these accounts it will be seen that the mode of pearl occurrence in Arkansas presents features somewhat different from those usually noted. Generally it has emed that the sandy and gravelly bottoms were most favorable for the pearl-hunter, nd the larger and older shells the most productive, while all the pearls have been ken from the living Unios. Here, on the other hand, appear these novel conditions f the pearls being apparently lost or washed out from the older shells and lying in he mud bottoms or carried long distances by floods, while the younger shells, if the bservation of Mr. Sharum be correct, are more apt to contain them. It will be interesting to ascertain more precisely the facts upon these points, to see if the loss of the ose pearls is a habit belonging to some particular species of Unios, and whether it is ccidental, or how far the local tradition of "shedding" them has any basis in fact.

Of course, if pearls were lost in these ways in gravelly or rocky streams, it is easy o see that they would soon lose their beauty by attrition among hard pebbles, and ecome indistinguishable from them, or be washed into the crevices of rocky beds; o that such pearls would scarcely be preserved or noticed, save in regions of mud ottom like those of the Arkansas bayous. It is clear also that only the rounded and erfectly free pearls would be lost in this manner, with the result that those found nder such conditions would present a very unusual proportion of large, well-shaped, nd hence valuable pearls, as compared with the ordinary gathering of them by opening the shells. This is precisely the case; the occasional pearls found at previous imes, and those that first attracted notice and brought on the excitement, were of rge size and round or well formed, and so brought high prices. Later, when almost he entire population at many points turned out, and all other work was abandoned or pearl-hunting, and the Unios were gathered and destroyed by tens of thousands ll along the streams through whole counties, great quantities of imperfect, irregular, nd defective pearls were obtained, with only an occasional one of value.

The pearl excitement of 1897 seems to have developed from several distinct centers, hrough accidental discoveries in the latter part of the summer as the water became ow in the rivers, lakes, and bayous. Specific accounts of these separate starting-points ave appeared in the local papers. The first to become highly important was the iscovery of a good pearl on the muddy shore of Murphy (or Crooked) Lake, by a oung man from St. Louis, who was spending his vacation on a fishing trip. Seated n a log, he noticed this bright object on the ground and, on picking it up, judged it to e a pearl. His negro guide told him that such objects were abundant at some points hereabout, and took him a mile or two through the woods to a spot where a number f similar pearls were easily picked up. The guide was amused at his interest in hem, and told him that they were of no use except as playthings for the children. He evertheless gathered a quantity of them and sent samples by mail to St. Louis and lemphis. In reply he was informed that they were true pearls, and the Memphis ewelry house sent him a check far beyond his anticipation. He then sent other parcels,

and gradually the matter began to attract attention in the two cities named, until Mr. J. A. O'Hara was sent by a Memphis firm to investigate. On his arrival, he found the conditions to be such that he promptly forwarded his resignation to the house, and went into pearl-collecting on his own account. Hon. J. J. Williams, of Shelby County, Tenn., then visited the region, with experts from St. Louis. In three days they found over forty pearls up to "the size of an acorn," valued at several hundred dollars, generally perfect in form, the larger pink and the smaller white. Mr. Williams immediately arranged with Mr. George C. Griffiths, of Bald Knob, the owner of the land, for a lease of the property on which Murphy Lake is situated. A Memphis syndicate was formed, which claimed entire control of the waters, set up notices of warning against trespass, built a house on the shore, and proposes to make a complete and systematic exploration of the mud by means of dredges.

The waters included in this lease are those of Murphy (or Crooked) and Walker (or Miller) lakes; these are bayous or expansions of tributaries of White River, about 100 miles west of Memphis. They are beautiful sheets of water, surrounded by a dense growth of cypress, and have long been favorite resorts for hunting and fishing for all the region around. Murphy Lake is about 2 miles long and some 800 feet in its greatest width; Walker Lake is only half as long, but much deeper, being 15 feet or more, even in low-water seasons, while Murphy Lake can be waded through at many points. The waters are somewhat impregnated with iron, and the district is reported to be malarious. The lease was drawn for five years, at the price of $4,500. As soon as it became known, much local opposition was aroused, and legal obstacles were interposed, on the ground that portions of the shore were Government land, school land, etc., and that the lakes were part of a public waterway and could not be preempted. The Williams-Memphis syndicate had operated from Bald Knob, White County, which is the nearest town on a main railroad line (the St. Louis and Iron Mountain), and the opposition was especially developed at Searcy, the county seat of White County, some 10 miles west. A party from that place, headed by the mayor, with several leading citizens, went to Murphy Lake to insist upon their right to hunt pearls there, despite the posted notices of the lessees. Both sides were armed with legal papers to prove their claims, and with shotguns also—presumably intended for game. After considerable friendly controversy, matters were left to the courts, and the Searcy party withdrew to another neighboring lake, of similar character but not preempted, to conduct pearl-hunting there in peace. The Memphis company has remained in possession and been actively at work, the lake being guarded by an armed patrol, and illuminated at night by a chain of gasoline lights, to prevent trespassing. At last advices they were paying all expenses and making some profit, though no particulars are given.

Other accounts of separate origin are reported from several points. An inmate of the Confederate Soldiers' Home, near Little Rock, while on a leave of absence, obtained some pearls on the Saline River; finding them to be valuable, he applied for an extension of furlough; and soon the story got abroad, and the furore began all along that stream. At the other end of the State, on Black River, a farmer while fishing opened a shell for bait, and found a pink pearl; this was late in July. A local jeweler gave him $25 for it and sold it in St. Louis for $200. The craze broke out in consequence, and the Black and Cache Rivers were soon lined with pearl-hunters. About the middle of September Mr. J. M. Pass, a well-known planter, while fishing in Dorcheat Lake, Columbia County (the southwestern part of the State), opened a

few mussels as an experiment, and obtained four good pearls; one of these he sold for $125, and the usual excitement arose through the entire neighboring region.

In these ways the pearl-hunting mania was started, and spread from stream to stream. So complete was the absorption of the people in this pursuit, that the local papers at various points reported much difficulty and apprehension on the part of planters as to the prospect of getting in their cotton and other crops, all the farm hands and negroes being occupied in an eager search for the anticipated fortunes in pearls. By the middle of September the jewelers at St. Louis began to be flooded with letters and parcels containing Arkansas pearls. Everything in the shape of nacreous concretions was sent, and very often the whole lot was not worth the postage or expressage that it cost; and the extreme disappointment of the finders, together with the clearing out of all the accessible shells from the "worked" streams, led to the decline of the craze.

There is no question, however, that large numbers of fine and valuable pearls were obtained, especially by the earlier explorers. A few notes are here given as to the sizes and values reported. A general agreement appears as to the large pearls being pink in color, and the smaller white. This probably indicates two species of shells. One deep pink pearl of 40 grains found in the mud by a woman was sold in St. Louis for $100, and as it was perfectly round and of fine luster its real value was much more. A farmer's boy obtained a pink pearl of 31 grains on Black River, near Black Rock, Lawrence County, and sold it for $35. The local purchaser took it to St. Louis and there refused $75 for it, offered by a leading house, and left it for sale with another firm, who found a buyer for it at $500. This was doubtless excessive. Other instances have been mentioned above, and the St. Louis and Arkansas papers report numerous cases of pearls up to 40 grains, that were estimated to be worth several hundred dollars when perfect. By the end of August, Mr. Smith, of West Point, White County, had sold pearls to the value of $1,200, taken from Seven Mile Lake, somewhat south of the Walker and Murphy lakes, and Mr. Thomas, of Bald Knob, had realized $1,500 from pearls from the Little Red River.

The region of the bayou lakes is reported to be unhealthy, at least for long-continued work in the water and mud, under conditions of exposure and fatigue such as pearl-hunting involves. Nevertheless, among thousands who camped out along the river banks for weeks during the autumn there does not seem to have been any frequent or serious illness.

Passing to a brief reference to other States, allusion has been already made to the pearl mania as extending into the Indian Territory. In the early part of September reports began to come from South McAlester, on the Kansas and Texas Railroad, of rich discoveries along the Kiamichi River, some distance to the southeast, and large numbers of people went thither from Arkansas, reporting the White River and its branches "cleaned out" and the shores covered with the opened and cast-away mussels. A little later quite a number of pearls, some reported as worth $100 apiece, were brought over the border to Paris, Texas, the county seat of Lamar County, from Boggy River, Indian Territory. Both this and the Kiamichi are northern affluents of the Red River, in about the central-southern part of the Choctaw Nation.

Louisiana does not seem to have been affected as yet, but it is quite probable that a similar excitement will develop there soon. A lady owning a plantation on the Tensas River obtained some pearls there before the war; she then set a number of little negroes to search for them, and thus procured others. Some of these were fine enough to be sent to New York and mounted in handsome jewelry.

Kansas has yielded a few valuable pearls. Eleven lavender-colored ones were brought to a leading jewelry house in St. Louis. The best was rated at $350, and others at prices ranging from $50 to $150, the whole being worth $600.

Missouri has furnished numerous reports; the earliest, at the beginning of September, came from Poplar Bluff, Butler County, in the southeastern part of the State, where a fisherman in opening Unios for bait found two fine pearls, one pink and one straw colored. This was on Black River, already mentioned in its southward extension into Arkansas. The usual result followed, thousands turning out to search the stream A number were taken to St. Louis later, but most of them proved of little account.

A fisherman living near Warsaw, Benton County, has been accustomed to bring into Sedalia, every autumn for five or six years, a little bag of pearls taken during the season from the Osage River. His annual sale has varied from $30 to $140. Other streams reported as yielding specimens are the Pomme de Terre and the Sac rivers, and Medicine Creek, which rises in Iowa. Plans were on foot at Greenfield, Dade County, to dredge the Sac River in that vicinity and explore the mud. The latest account is from near Cuba, Crawford County, on the Meramec River, where two fishermen, on an excursion from St. Louis in November, got a farmer to drive across the stream with his drag shovel. The result was that they obtained at one "haul" three loose pearls and 301 mussels, which yielded 207 pearls, up to the size of a pea. The proceeds were shared between the three parties, but the farmer, who owned the land, forbade any further operations.

Tennessee, where for years past the whole subject of Unio pearls has been familiar, has not been so much excited as the States where there was more novelty and less experience in pearl-hunting. But while the former yield was chiefly along Stone River or Caney Fork, and then somewhat on the Calfkiller, Elk, Duck, and other tributaries of the Cumberland and Tennessee, and the main streams also in the central and western portion of the State, the last two or three years have witnessed great activity in a rather new district, in East Tennessee, along Clinch River. In the former region the business has settled down substantially to pearl-hunting in a moderate way by fishing parties in the summer, and by farmers in the fall, who camp out on the river banks after the crops are gathered in and dredge the streams with some system. Along Clinch River, however, the past season has witnessed all the incidents of the first excitement; and quite vivid and picturesque accounts were published of hosts of people camping along the streams, some in tents, some in the roughest shanties, and some going from shoal to shoal in rudely-built house-boats. Many pearls are reported as having brought $100 or more. The hunters are described as a lively, free-and-easy set of people, working hard all day, subsisting a good deal on fish caught in the river, and dancing at night to the banjo around the camp-fires that line the banks.

In the older pearl region of Tennessee considerable activity has prevailed along Duck River, and large prices are claimed. Much local excitement has also been announced from Smithville, Dekalb County, and Arlington.

In Kentucky an aged fisherman is reported as having obtained a large number of pearls—one of them worth $70—at the mouth of Little River, which enters the Cumberland in Lyon County.

In Indiana a few discoveries in the central part of the State have led to considerable newspaper comment and some excitement. Toward the end of August some fine pearls were found in White River only a few miles from Indianapolis. Prices

were reported by jewelers in that city up to $300. Others were taken from the Wabash and Eel rivers, and it is stated that the inmates of the Soldiers' Home at Marion, Grant County, made a regular occupation of pearl-hunting in the Mississnewa, an affluent of the Wabash, and that two of them had realized $400 for their season's work. Some pearls were also obtained near Rushville, in Flatrock Creek, but no details were given.

In Michigan a plan is on foot, organized by Grand Rapids capitalists, to engage a large number of laborers and operate systematically along the St. Joseph River next year. Many smaller schemes are also being planned. Multitudes of shells were gathered during the past season, and many good pearls reported from that river in the southeastern corner of the State.

In Wisconsin the only important pearl discovery was reported from Janesville early in August, when two farmers found two pearls in Rock River, which they sold for $200 each. One of them was subsequently, it is said, sold in Chicago at a great advance. Beloit and Marinette are also mentioned as places where some interest has been developed.

In Iowa two men who were exploring along the Mississippi for a pearl-button establishment, to determine the quality and abundance of available shells, obtained a few pearls in a small inlet below Bisping's Springs. Only one was valuable. An interesting circumstance is that the pearl-yielding shells were found at the same spot, while hosts of others which they had opened and examined in the course of their business had no pearls whatever.

Georgia has developed some interest, principally in the vicinity of Rome, at the junction of the Etowah and Oostanaula. This is believed to be the site of the Indian town of Ichiaha, where DeSoto stayed for a time during his memorable expedition of 1540–41, and found the natives in possession of so many pearls. The Arkansas reports stirred up a local excitement in this region, when the river became low and clear in the autumn, and multitudes went searching the waterways. Ex-sheriff Mathias, of Rome, is reported as having some 50 pearls, brilliant but irregular. A few miles above, on the Oostanaula, Mr. Bennett, a farmer, on reading of the Arkansas furore, made a trial on John's Creek, a tributary of the Oostanaula; and from a basketful of Unios he obtained several fine pearls, up to the size of peas, for which he received $180 from a Baltimore jeweler to whom he sent them. Others followed, and many fine specimens were procured.

Florida has not yet been "worked," but it may prove a productive pearl region ere long. The reports of DeSoto's expedition make special reference to the size and beauty of the pearls at a point where he crossed the Oclocknee River, some 30 miles above its mouth. This place corresponds to what is now Langston's Ferry, Wakulla County, and there is little doubt that pearls may be found there now in the Oclocknee and its affluent, the Sopchoppy River. The banks are described as packed full of shells. Mr. Houstoun, a resident near that point, possesses some pearls, and specimens of them sent to the Philadelphia Exposition were much admired. Many pearls are reported as found worth from $30 to $60. The average size is about an eighth of an inch, which, when perfect, bring from $10 to $15. The two largest and finest weigh, respectively, 68 and 58 grains, and were sold for $850 and $600.

Connecticut has also had its pearl fever, again as a result of the press accounts from the Southwest. In October Mr. C. S. Carwell, an old and well-known hunter,

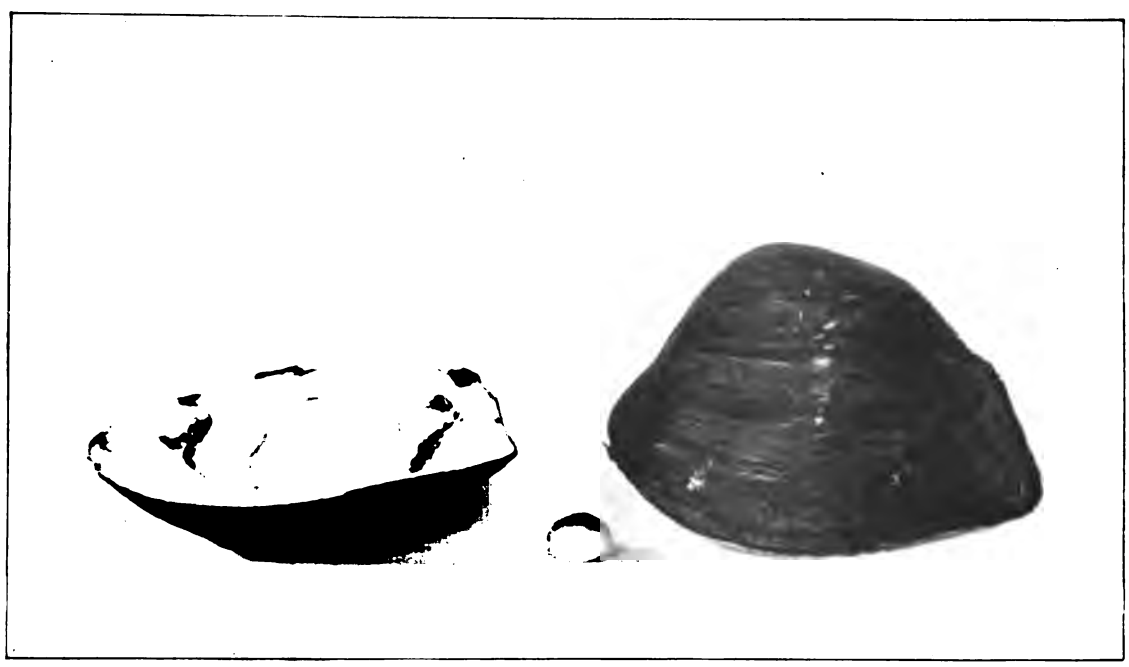
tried exploring about the headwaters of Mystic River, and after a few weeks had gathered a number of pearls, one of which he is reported as having sold for $500, and two others are estimated at $400 apiece. From the other end of the State, along the Shepaug River, in Litchfield County, comes an account of the success of Mr. Arlo Kinney, of Steep Rock. One fact here is of special interest. Mr. Kinney, instead of destroying every Unio that he examines, uses pincers, after the German method, to open the shell sufficiently to see if there is any valuable pearl, and then returns it to the water. If only this method, so simple and so reasonable, could be introduced throughout this country, enormous waste and destruction could be easily prevented. Crowds of seekers, however, attracted by the reports, have proceeded, here as elsewhere, in the usual reckless manner of wholesale destruction.

Water telescope in use.

In New York the pearl-hunting excitement has also been felt as a result of the prominence given in the papers to the Arkansas discoveries. The principal scene of activity has been in the northwestern angle of the State, along Grass River and its affluents, one of the streams that drain from the Adirondacks into the St. Lawrence. The central point has been the town of Russell, St. Lawrence County. Two years ago Mr. M. C. Rowe, of that place, on opening a mussel for bait, while fishing in Frost Brook, a tributary of Grass River, found a pink pearl as large as a pea. This he sold at a good price, and has since made several hundred dollars by collecting pearls thereabouts. During the past season there has been great activity, and multitudes have been pearl-hunting.

The streams here are clear and rapid, and those who make it a business have special outfits for the work. A rubber suit is worn, consisting of boots and long trousers in one piece, with which they wade up the stream, each having slung about his neck a perforated tin-pail. To the face is strapped the "water telescope," i. e., a light square wooden box, open above and shaped to fit to the face, and closed below with a piece of glass. The pearl-hunter walks in a stooping posture, with the lower end of the box immersed, so that he can see the shells lying on the bottom, and take them with a "spud," or pole carrying at the end a pair of spring clasps or nippers.

*A*

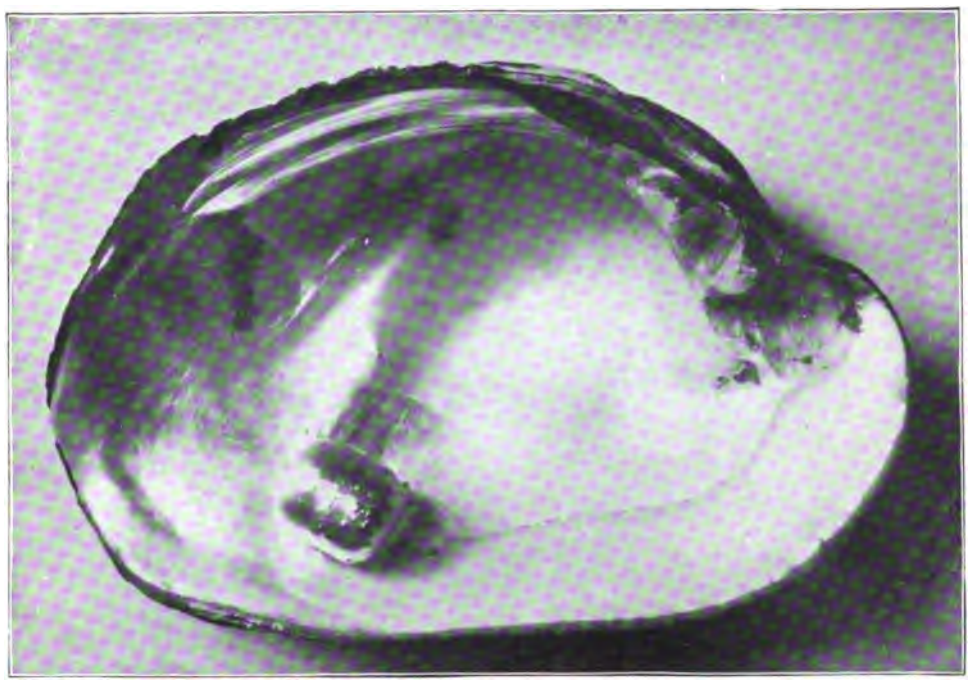


*B* *C* *D*

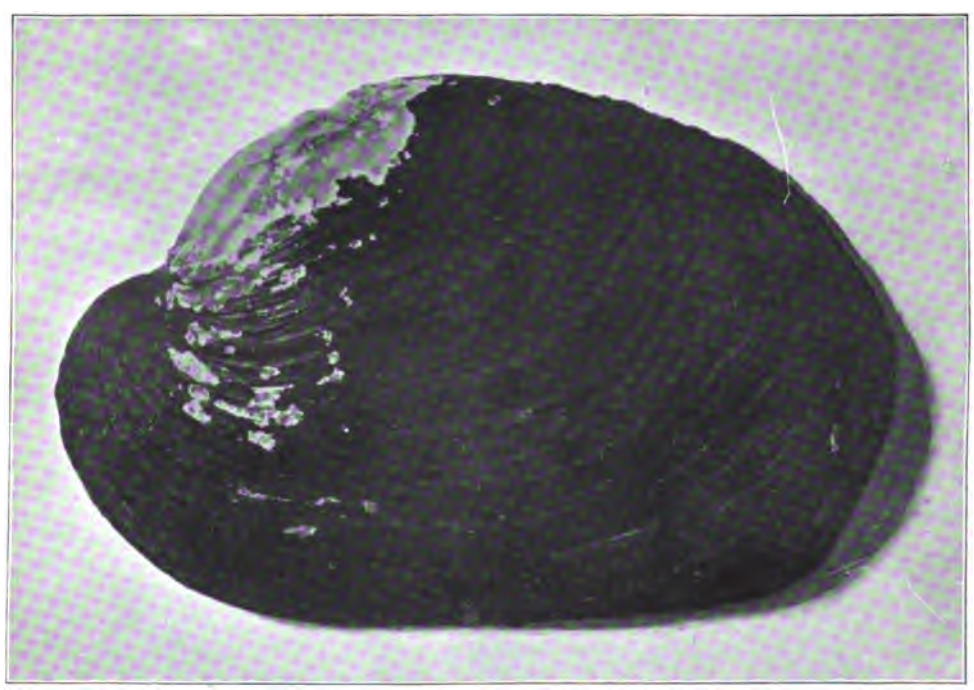
SALMON-COLORED PEARL, WEIGHING 14½ PEARL GRAINS, LYING LOOSE WHERE IT WAS FORMED IN A SHELL. FROM LINN JUNCTION, IOWA.

The pearl is nearly hemispherical, or "button-shaped," somewhat one-sided, but perfect above. It occupied a depression at the posterior end of the right valve, and had caused a marked outgrowth or protuberance of the other valve.

*A*. Interior view of the right valve, with the pearl in place.
*B*. The same valve with the pearl removed, showing the depression where it had lain.
*C*. The pearl itself taken out.
*D*. Exterior view of the left valve, showing the protuberance corresponding to the pearl.



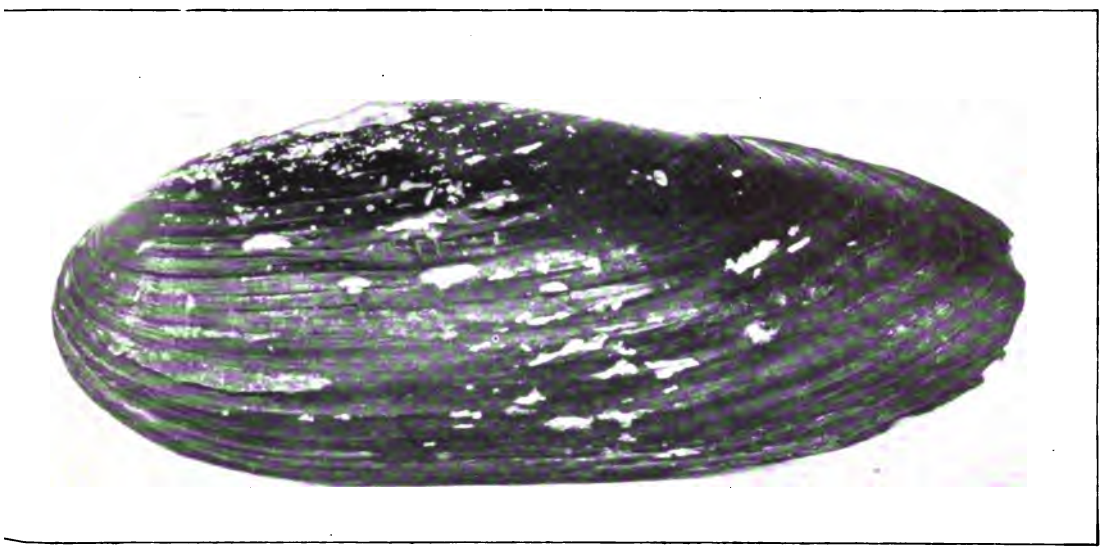
*A.* Interior of shell showing barrel-shaped adhering pearl of large size.

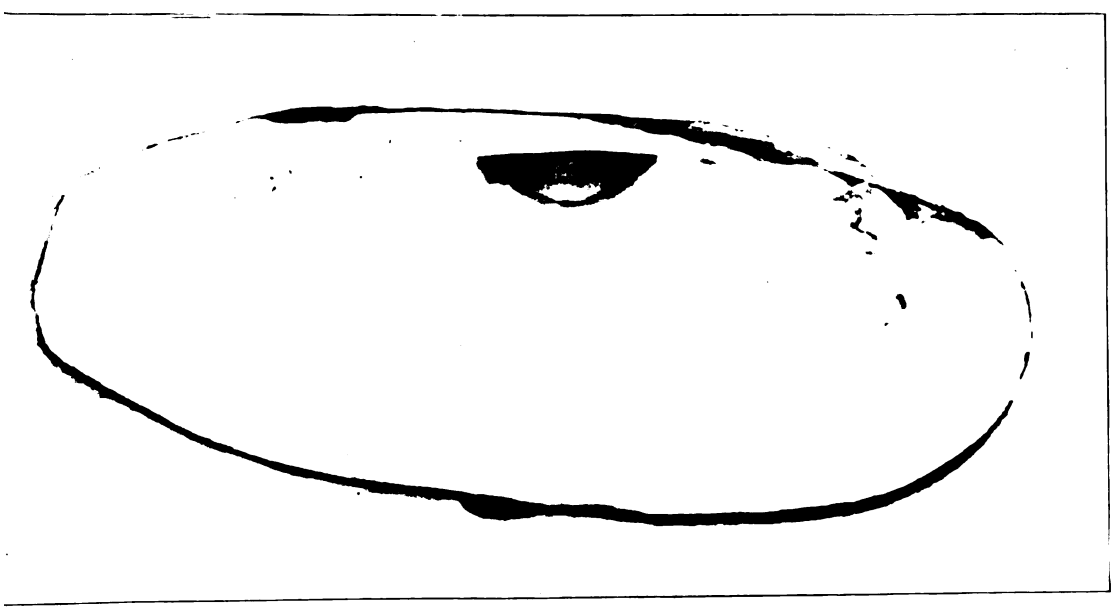


*B.* Exterior of same valve of shell.

A TYPICAL UNIO OF THE MISSISSIPPI VALLEY TYPE, SHOWING EXTERIOR OF RIGHT VALVE AND INTERIOR OF LEFT VALVE.

This is a full-grown shell, but not an old one, as the dark epidermis is but little eroded at the beaks.





LEFT VALVE OF UNIO RECTUS, OUTSIDE AND INSIDE VIEWS.

The latter showed an extremely irregular mass of rich purplish nacreous matter, with many protuberances, lying between the hinge and the anterior adductor impression, and partly occupying the space of the latter. The shell is almost entirely white. The pearly pertuberances at the right of the hinge are of a rich purple color. The shell is pure white.

## INVESTIGATION BY THE UNITED STATES FISH COMMISSION.

In view of the great interest and possible importance of the discoveries from time to time made in various parts of the United States, and particularly in the Mississippi Valley, of pearls yielded by the fresh-water bivalve shells (*Unionidæ*) so abundant in many of our inland waters, a systematic inquiry was undertaken in 1894 by the United States Commission of Fish and Fisheries, to ascertain as far as possible the facts relating to the occurrence and distribution of the pearl-bearing species and the extent and conduct of the pearl industry as thus far developed. The value and elegance of many of these pearls, especially as shown in exhibits made at the Columbian Exposition in 1893; the popular excitements or "pearl fevers" at times arising in districts where a few pearls have been found, and characterized by wholesale and reckless destruction of the shells over large areas; the total lack of system in the search for pearls, as contrasted with the methods that have been developed on a smaller but far more profitable scale in Europe, all seemed to call for a careful investigation by the Commission, with a view to better knowledge and wiser direction in the matter of inland American pearl fisheries.

To this end a circular was prepared and issued in 1895, comprising a series of thirty inquiries relating to the habits and distribution of the shells, the frequency and value of pearls obtained from them, the methods and extent of the industry, and various related points. This circular was sent out to several hundred persons in all parts of the country east of the Rocky Mountains, who could be heard ot as at all likely to feel interest or possess experience relating to the subject. The circular called for information on the following special points:

*The pearl-bearing mussels:*

1. Nature of stream in which found; kind of bottom; character of water.
2. Geological character of the district as to rock, soil, etc.
3. General abundance of mussels.
4. Size, shape, and position of the mussel-beds.
5. Local names of mussels.
6. Habits of mussels.
7. Enemies and fatalities to which mussels are exposed; nature and extent of destruction by muskrats, hogs, freshets, etc.
8. Size, shape, and color of mussels.
9. Species of mussels in which pearls are most common.
10. Proportion of mussels in which pearls occur.
11. Sizes, or other peculiarities, of shells in which pearls are found.

*The pearls:*

12. Nature and origin of pearls.
13. Position in mussel.
14. Size, shape, and color of pearls.
15. Relative value of pearls in different sizes, shapes, and colors.
16. Markets for pearls.
17. Prices for pearls.

*The fishery:*

18. Method of taking the mussels.
19. Description of apparatus used in taking mussels and in opening the shells.
20. Methods of extracting the pearls.
21. Treatment of pearls when found.
22. Utilization of mussels after extraction of pearls or after opening.
23. Principal occupations of mussel fishermen.
24. Statistics of fishery: Fishermen, boats, apparatus, pearls.
25. Comparative statistics of pearls, etc.
26. Period when pearl-fishing was of greatest importance in district.
27. History of origin and growth of fishery.
28. Exhaustion of mussel-beds; causes, rapidity.
29. Do exhausted beds become replenished, and in what time?
30. Is State protection of the beds desirable or necessary?

To this circular 123 responses were received, besides a few that were so absolutely indefinite and obscure as to possess no value. The replies came from the following States—more than half of them from Tennessee, where of late the greatest activity has prevailed.[1]

| | | | |
|---|---|---|---|
| Alabama | 1 | Massachusetts | 1 |
| Arkansas | 3 | Michigan | 1 |
| Florida | 1 | Mississippi | 1 |
| Illinois | 3 | New York | 4 |
| Indiana | 5 | Ohio | 1 |
| Iowa | 6 | Pennsylvania | 1 |
| Kansas | 3 | Tennessee | 74 |
| Kentucky | 2 | Texas | 6 |
| Maryland | 2 | Wisconsin | 8 |

These responses contain a large amount of valuable information. Many of them are furnished by persons not at all in the habit of writing, but who are evidently very familiar with the facts through much experience and observation. The general results are quite clear as to some of the points, and conflicting as to others; this last condition is easily seen to be due to local differences in the very wide area covered, and to the fact that the species of Unios and, to some extent, their habits are different in the different sections of the country. A great desideratum seems now to be a scientific determination of the particular species referred to in these reports and designated by vague or fanciful local names.

To the first inquiry, relating to the nature of the stream and the character of the bottom and of the water, only four of the papers failed to respond more or less fully, though only a part of them include answers to all the three points in the question. In summing up the results, the first, second, and third points may be considered together, with the following result: Thirty-nine papers report the stream as swift, and 7 as slow; 31 give the water as clear, and 2 as muddy; 15 mention it as shallow, and 6 as deep, and 22 refer to it as being more or less "hard." A number of the answers are less easily classified, describing different streams in the vicinity, or the same stream at different points and different seasons, as varying in depth and in the rate of flow. As regards the bottom, many papers report several kinds, as sand or gravel, or both, on a rock bottom, or areas of mud with rock or sand, etc. The most definite statements may be grouped as rock, 35; gravel, 76; sand, 49; mud, 32, including a few references to clay.

The general indications from these data are quite plain, to the effect that the shells are chiefly found in rather rapid streams, in which the bottom would naturally

[1] It will be noticed that all these responses were sent before the pearl excitement of 1897, in Arkansas and adjoining States, described on pp. 395–401, above, in which some new and additional aspects were developed.

be sandy or gravelly and the water clear. Other species, however, occur on muddy or clayey bottoms, where the current is slower. The references to rock bottom do not concern so much the immediate surface where the shells are found as the underlying bed on which the softer materials rest. In the matter of depth, also, the large preponderance of answers in favor of shallow streams may mean not so much that the Unios greatly prefer shallow water as that they are more readily found and gathered there. The frequent allusions to "hard" or calcareous water tend to confirm the general impression that streams of this kind are favorable to the development of molluscan shells in both size and abundance.

A few references to peculiar conditions may be noted, *e. g.*, the Florida paper states that the best Unio growth is found in lakes with outlets, the water pure and fresh, but adds that it is sometimes sulphurous. One Texas paper (Colorado, Concho, San Saba, and Llano rivers) refers to the water as becoming slightly alkaline in dry times, and another (Colorado and Llano) makes a similar statement. A New York paper (De Grasse River and Plum Brook) mentions the water as brown or black—the clear, brown water of hemlock districts, familiar in northern New York. Iowa and Indiana papers state that spring-fed streams seem to be most productive of Unios, and a New York account, describing them as found in rapid, gravelly streams, over limestone rock, adds that they are most abundant where the country has been cleared, "as the water is apt to be harder there."

The second inquiry, as to the geological character of the district, its rock, soil, etc., has been answered in 95 papers, more or less fully, though some refer only to the nature of the soil, or are otherwise incomplete. Of course no very exact scientific accounts could be looked for in such a body of responses, and the statements given are, for the most part, of a general character, though some are more detailed, and a few specify the geological horizon of the rocks at the localities described. Dividing the answers into two sets, one for the country rock and the other for the soil, they may be summed up as follows:

*Country rock:* Limestone, 69; sandstone, 21; slate (and shale), 9; "flint" (or chert), 7. A few others are mentioned, viz: The Florida paper reports only "sand overlying clay or hardpan" (sand cemented by iron oxide), and Mississippi "only sand, gravel, and mud; no rock." New York reports "iron-ore"; Pennsylvania, "coal," and Texas "limestone and granite." In many cases two or three of the rocks above named are mentioned in the same paper as associated in the region.

*Soil:* Sand, 34; clay, 19; loam, 10; and a few other designations, as "mixed," 1; "black," 8; "calcareous," 2, etc. In many cases two or three of these kinds are named together, as "sandy and clayey," "sandy loam," and the like.

The inference from these data is closely corroborative of that from the first inquiry—that a limestone region is favorable to the development of Unios. The nature of the soil seems to be of little or no importance in relation to the shells, as compared with the underlying country rock, outcropping or exposed in the river bottoms or along the bluffs. An Iowa paper remarks that "the presence of lime gives greater luster to the pearls," and several allusions point to a general impression as to the advantageous character of a calcareous region.

The principal geological references are the following: An Arkansas paper specifies the rocks of the district as "the magnesian limestone of the Lower Silurian, and encrinal marble and chert (Devonian); soil calcareous, with more or less sand." The Ohio paper gives limestone and some shales, of Niagara, Clinton, and Cincinnati age (Silurian). One Tennessee circular refers to the Lebanon group (Lower Silurian) and

another to sub-Carboniferous and Trenton. Two of the Wisconsin papers mention limestone underlain by Potsdam sandstone and associated with St. Peter's sandstone. Of course the rocks of the Mississippi Valley are for the most part well known, and the particular horizons here mentioned, so largely confined to the earlier Paleozoic, can have no special significance in the present connection, as only the chemical composition of the rocks could affect the abundance of the Unios, if, indeed, the limestone theory be as important in this respect as is generally believed. It may be observed here that in several papers which make no mention of limestone or specify other rocks instead (Illinois, Michigan, and Texas, sandstone; Florida and Mississippi, sands and clays) there seems no dearth of Unios in the streams and lakes.

Out of 107 papers which respond definitely to the third inquiry, as to the abundance of mussels, 10 describe the shells as at present very abundant, 47 as plentiful, 36 as scarce, and 4 as absolutely exterminated, while 34 papers refer to the fact of diminished and diminishing numbers within a few years past, some of them with great emphasis. Three Tennessee papers estimate the present numbers as reduced to one-tenth of what they were ten years ago, and in a number the same general fact is stated—of former abundance and present rarity—and attributed to the pearl-hunting destruction of recent years. Several papers say that the shells are now scarce in small streams and the shallower parts of larger ones, while still abundant in deep water and where the currents are strong. The answers in detail are as follows:

*General abundance of mussels.*

| State. | Very abundant. | Abundant. | Few. | Diminished. | Exterminated. | No. of papers reporting. |
|---|---|---|---|---|---|---|
| Alabama | 1 | | | | | 1 |
| Arkansas | 3 | | | | | 3 |
| Florida | | 1 | | | | 1 |
| Illinois | | | 1 | 1 | 1 | 3 |
| Indiana | | 1 | 1 | 2 | | 3 |
| Iowa | 2 | 2 | 1 | 1 | | 4 |
| Kansas | | 1 | | 1 | | 1 |
| Kentucky | | 1 | | | | 2 |
| Maryland | | 2 | | | | 2 |
| Massachusetts | | | 1 | | | 1 |
| Michigan | | 1 | | | | 1 |
| Mississippi | | 1 | | | | 1 |
| New York | 1 | | 1 | 1 | | 3 |
| Ohio | | | 1 | 1 | | 1 |
| Pennsylvania | | | 1 | | | 1 |
| Tennessee | 1 | 34 | 28 | 21 | 1 | 66 |
| Texas | | 3 | 1 | 2 | 1 | 5 |
| Wisconsin | 1 | 1 | | 4 | 1 | 7 |
| Total | 9 | 48 | 36 | 34 | 4 | 106 |

In response to the inquiry as to the form, size, and position of the beds, the answers are very various, indicating much diversity of conditions, depending evidently on the species of shells and size and character of the streams. A Wisconsin report states the river to be "nearly all mussel-bed for 100 miles." A Tennessee report states that shells lie scattered over the bottom and not in beds, and reports from Iowa and Massachusetts make similar statements. Some 39 papers give estimates of the size of the beds,

varying extremely; several describe the shells as occurring in small patches of a few feet square, but the large majority agree in giving the beds an elongated shape, either along the banks or on shoals in midstream. In the smaller rivers they extend all across, up to a width of the stream of 100 yards (Tennessee). The length of these beds is estimated at from a few yards to several hundred, or in some cases a mile or even 4 miles (Arkansas). They are in some cases reported as upon sandy or gravelly bottom, in shallow water of moderate swiftness, and a few speak of the shells as wedged in among the crevices of rocky or stony bottoms. Very few refer to still water or mud.[1]

In two papers (Florida and Illinois) some of the shells are described as in the bank, from 1 to 4 feet below the surface of the water. This occurrence is peculiar, and it would be of interest to ascertain what species possess this habit.

In several instances the shells are reported as packed side by side on the bottom so closely as to be like a pavement (Tennessee and Wisconsin), and sometimes several layers deep in places where there are "holes" in the bed of the stream (Wisconsin).

The Florida paper states that in lakes the beds extend around the shore, their breadth determined by the depth of the water.

There is a general agreement that the midstream beds are upon shoals or connected with islands, bars, or rapids. But the detailed statements vary, some placing them above and others below rapids, and likewise as to islands. Evidently they occur for the most part in places where there is a moderately rapid flow, but somewhat protected from the full force of strong currents. Some interesting particulars are given. One paper (Tennessee) says that the shells lie in beds from shoals up to deep water, where there is rock bottom, and then in crevices in the rocks; and two others (Tennessee) are somewhat similar. Another (Tennessee) reports them as usually at the head of an island above the "breakers," usually opposite the bluff side. An Iowa paper speaks of the beds as extending along bold banks until the current changes to the opposite side, i. e., on the swifter (convex) sides of the curves. The author of a Maryland paper states that the beds vary in location with the varying distribution of the sand and mud of the bottom, the shells traveling correspondingly if the changes are not too sudden. One paper from Texas refers to their seeking and occupying positions where they are best protected from the force of the current in freshets.

It is clear, from all these varying accounts, that the location of the shell-beds is determined by conditions which depend on the size and the rapidity of the stream and the nature of its banks and bottom; the main requisite being water of a very moderate depth, flowing freely but gently, and so producing almost always a sandy or gravelly bottom. In shallow streams these conditions would extend all across; in larger ones they would be found near the shores, or associated variously with islands, bars, and rapids. In slow streams, the shells would naturally be found on the convex sides of the curves, where the swifter current erodes the banks; in more rapid ones they would seek the slower portions of the river, and avail themselves of the shelter of islands, etc., as a defense against the violence of freshets. This last agency is spoken of by several, in the answer to another inquiry, as being highly destructive, especially to the younger and the smaller shells; hence, those without the protection of some island or shoal above them would be most liable to be swept away and destroyed in flood time.

[1] But on this point, see pp. 395–397, above, as to mode of occurrence in Arkansas bayous.

In regard to the local names of mussels, an immense variety of responses was received. In 96 papers 12 report simply "mussels"; 10, "clams"; 1, "clam-mussels"; 1, "oyster-clams"; and 5, "fresh-water clams." The rest are either descriptive names, due to some feature of form or color, or else purely fanciful appellations. Arkansas reports black mussel, white mussel, long white, short white, long red, thick-shell (or flint), oyster-shell, wrinkle-shell, and bedded mussel. Ohio sends long-pointed clam, round small clam, rough stone clam, bottle-shell, striped bottle-shell, blue-edged shell, paper-shell, razor-back, pumpkin-seed, and bastard. Pennsylvania (also Wisconsin, in one paper) gives two kinds, pearl mussel and common mussel. An Iowa circular says that the name "clam" includes some thirty varieties. Tennessee furnishes a host of names, black (24), white (13), yellow (44), pink (15), purple (4), blue (4), black-pink (1), lake (24), bullhead (18), hard-tack (6), fluted (7, including 2 called black-fluted), biscuit (9), she (10), rock (4), shark (3), heel-splitter (3), Nigger Dick (2), and one each of the following: gray, brown, red, broad-axe, Black Maria, sailaway, trigger-back, spike, gunboat, hatchet, thin-shell, deep-water, pocketbook, hawk-bill, fancy, speck-case, Jessie Cook, Dick, negro-heel. Four of these—the purple, Black Maria, hard-tack, and sailaway—are also reported from Kentucky. One paper identifies the "biscuit" and "black" mussel; one makes the "lake" the same as the "rock," and another the same as the "blue"; three identify the "lake" with the "fluted," and two mention them as distinct. One report says of the "bullhead" that there are several kinds of them. Wisconsin gives also quite a list—crinkly (2), horse-foot or soft-shell, heart-shaped or hard-shell, mullet-shell, rough hard-shell, checkered or purple-shell, smooth soft-shell, paper-shell, long blue, slipper-shell, oblong pink-lined, broad-stripe, and Mother Hubbard.

The scientific collector of Unios can easily conjecture from some of these names what species may be meant, but most of them are altogether indefinite for any purpose of recognition. Many of them doubtless are applied in different localities to the same shell, while others may be used for different ages and varieties of identical species in a single stream. It is highly desirable that specimens should be obtained of these variously designated shells in order to their scientific determination.

The question as to the habits of the mussels was answered more or less definitely in 60 papers. Most of these describe the shells as somewhat migratory in habit, according to various conditions, as to food, season, depth of water, etc. Only 7 (6 from Tennessee and 1 from Wisconsin) report them as almost entirely stationary. Six papers relate that at the approach of winter they withdraw from the shore into deep water and bury themselves several inches in the sand or mud, reappearing in the spring when the water is high; then, as the water falls, others relate that they follow it, seeking apparently a uniform depth. Similar migrations follow upon disturbance of the beds by caving of the banks (Texas) or other natural changes. Three papers refer to the young shells as more active than the old ones, and this is probably the meaning also of a statement (Tennessee) that the pearl-bearing shells are stationary and those that crawl of little value. Three papers refer to their being packed so closely side by side on the bottom that they can scarcely dislodge themselves to move about (Wisconsin and Tennessee). One report (Tennessee) says that while some are lying on the surface of the bottom the "yellow mussel" is in beds three layers deep, under gravel and sand. The Florida paper describes one species as living permanently in the sides of banks, sometimes above the water, and a similar statement is made in

an Illinois response, only that the shells are from 1 to 4 feet below the surface. One paper describes them as moving shoreward in the morning and back into deeper water later in the day (Illinois); another as feeding in the morning and evening (Iowa), and another as active at night and resting by day (Tennessee). In an Iowa paper they are reported as coming into shallow water to spawn in midsummer.

Here, again, is evidence of much diversity, according to the species and to varying conditions. Hibernation, by burying themselves at the approach of winter, is an interesting feature that seems in some cases well attested, though a Kentucky paper states that no difference has been noticed between winter and summer. The younger shells are clearly somewhat migratory, but the tendency of the older ones is in many cases, where they have found a secure and favorable bedding-ground, to become closely massed together by gradual increase of size, so that dislodgment or moving becomes difficult.

The responses to question 7, relating to the natural enemies of mussels, in 110 papers, are varied and interesting, and in some respects quite contradictory. The chief natural enemy of the Unios seems to be the muskrat. Ninety-eight papers refer to it, 40 reporting large destruction from this cause, 55 in some degree, and 3 denying any. Hogs come next, and are referred to in 67 papers. Of these, 9 hold them responsible for large destruction, 50 for some or a little, and 8 assert that there is none. Of other animals, raccoons are stated in 14 papers to destroy some shells; mink in 6 (New York, Iowa, and Wisconsin); mud turtles in 3 (Wisconsin); otter in 2 (New York and Iowa); crows in 3 (Tennessee); fish in 3 (Maryland, Ohio, and Texas); crayfish in 2 (Maryland and New York); aquatic birds in 2 (Florida and Illinois); bears in 1 (New York), and cattle, by trampling, in 3 (Maryland, Indiana, and Iowa). All the animal depredators deal only, or chiefly, with Unios that are either young, small-sized, or soft-shelled, and hence not largely pearl-bearing. The only exception to this general rule is the statement in one paper (Tennessee) that many pearls have been found where shells had been taken ashore by muskrats and left to open in the sun.

With regard to physical causes of injury the most serious, no doubt, is found in freshets. Of 39 papers that refer to these, 18 report great destruction thereby, 18 say "some" or "a little," and 3 deny that there is any. Some papers say that their injury is small and that they only shift the beds and redistribute them, but a number describe the burying of beds by washing down and caving in of banks in flood time or the stranding of great quantities of young shells, to perish when the water subsides. Two papers that do not mention freshets should doubtless be included here, however, as they speak of destruction caused to the shells by "covering with mud" and by "change of bars." On the other hand, low water and droughts are reported as seriously harmful in 7 papers and drift ice in 4. Three papers allude to disease as a cause of injury and 3 to boring parasites.

By far the most dangerous foe, however, is man, as his activity in pearl-hunting has nearly exterminated the shells at many points and greatly reduced them at nearly all. Twenty-six papers make mention of human agency as a destroyer, 14 of which regard it as the most serious and some as the only one of moment. Even where pearl-hunting has not yet extended, large numbers of Unios are used by fishermen for bait.

Questions 8 and 9 were answered in a large majority of the papers, but in a manner so general and indefinite that little can be derived from them for a report. The answers to question 8 are chiefly unscientific statements as to sizes and colors that

do not indicate the species with any precision, while those under question 9 have the same uncertainty, as the terms employed to designate the shells most prolific in pearls are the local and popular names already mentioned under the head of question 5.

In response to question 10, as to the proportion of shells in which pearls are found, the answers vary so much that no general result can be gathered from the estimates. This extreme diversity is due in the first place to the fact that no standard meaning is attached to the term "pearls," some of the papers including any such objects found in the shells, while others confine the answer to those that have marketable value. This, of course, involves very great differences, as the small and irregular pearls are somewhat common, while those of good size, form, and luster are, by all accounts, very rare. Other differences are due to natural causes, the productiveness in pearls varying with different species, different conditions, different streams, and different years.

The estimates given in 78 papers which undertake to answer the inquiry range from 1 pearl in 20 to 1 in 100,000 (Iowa). A paper from Michigan and one from Tennessee give a ratio of 1 in 20; five give 1 in 50, nineteen 1 in 100, five 1 in 200, two 1 in 300, five 1 in 500, ten 1 in 1,000, and so on up to 1,500, 3,000, 6,000, 10,000, etc. Many state that the proportion varies in different streams; thus a New York paper says, for the main branch of De Grasse River, 1 in 3,000; for the north branch, 1 in 500; and for small brooks in the neighborhood, 1 in from 300 to 800. Others refer to differences in different species; thus a Tennessee circular gives 1 pearl in 5,000 of the "yellow" mussel, 5,000 to 6,000 of the "rock" or "lake" mussel, 8,000 of the "biscuit," and 10,000 of the "black"; in other species even scarcer. This is for pearls valued at $25 and upward. Others allude to differences in seasons; thus the Maryland paper states that 5 bushels of shells yielded 3 pearls in 1888, while none were obtained from 160 bushels in 1889. Several papers make no attempt at an estimate, and simply state that valuable pearls are "scarce" or "very scarce."

In the answers to question 11, as to whether the pearl-bearing shells display any distinguishing peculiarities of size or form or other features that may indicate the presence of pearls within, the same diversity appears, in some respects, that has been noted under several of the previous heads, and for the same reason, no doubt, viz, differences of locality and of species. Eighty-eight papers make more or less response to the inquiry; of these, 17 are undecided or indefinite; 11 state positively that there are no criteria; 14 say that pearls occur chiefly in large shells, 32 in medium-sized, and 8 in small; 3 state that the presence of a large pearl is indicated externally by a bulging or protuberance of the shell (New York and Tennessee), or by a ridge (Tennessee); 8 refer to some peculiarity of form as indicative, but rather vaguely, and 2 (Tennessee) observe that the shells appear to have been injured at some time. Several refer particularly to old or old-looking shells, and to those of rough aspect or moss-grown, while a New York paper specifies "the brightest and clearest." Many state that young and small shells contain no pearls of value, as would naturally be expected. Several mention particular kinds as the best, using the local names; but these answers belong properly under question 9.

Question 12, as to the nature and origin of pearls, in the view of those familiar with their occurrence in the fresh-water mussels, has brought out a general agreement among the majority of those who respond, in favor of the usual theory that they are due to the presence of some irritating foreign substance. Other views are

presented by some; and several writers send observations of rather curious interest. Only 51 of the papers answer the question at all, of which 30 pronounce more or less positively in support of the intrusion theory, as above mentioned; 8 are doubtful or non-committal; and 8 advocate the view that pearl production is due to injury or disease. Three papers (Illinois and Tennessee) state that the pearls are at first soft or gristly and acquire hardness and luster gradually later; and one from Texas reports finding them in various stages of growth before they were "glazed over." The Florida paper, while accepting the intrusion theory, claims that all valuable pearls are formed upon an egg which the mollusk has not succeeded in extruding. This suggestion might easily be thought to afford explanation of the peculiar statements in the four papers just referred to.

Interesting notes are given in an Indiana response, where the writer speaks of finding a little twig in a shell "partly petrified" (i. e., pearl-coated?), and in an Iowa paper, where the writer refers to finding grains of sand and gravel partially coated with pearl nacre. One paper affirms that they were "originally created" with the mollusk, and bases this opinion on the fact that large pearls are found in small shells, at least sometimes. One paper (Indiana) which advocates the theory of injury refers to the fact that the pearl-bearing bed is close to a steamboat-landing, and considers the frequent disturbance of the water as a favorable condition. It is apparent, however, that this fact might operate quite as effectively in behalf of the intrusion theory.

Question 13, as to the position in which pearls are most frequently found in the body of the mussel, is answered by a very large proportion of the responses, and with a good deal of variety, though the general results are pretty clear. A difficulty conspicuous in these answers is the lack of definiteness in the terms employed to denote the parts of the shell and the body—the words varying much in the use of different individuals and affording a striking illustration of the value of exact scientific terms as compared with ordinary phraseology. Notwithstanding this fact, however, it is not hard to ascertain what is meant by most of the writers, and indeed many have expressed themselves very clearly, and only in a few cases is the real meaning obscure.

To this question 112 answers have been received; several uncertain or indefinite—some merely saying that the pearls are found between the mantle and the shell, or similar expressions of an indeterminate character; 16 refer to them as occurring in or near the hinge, but most of these also state that such pearls are rarely valuable or well-formed, being generally "slugs"; 44 specify the borders of the mantle as the chief location for free and valuable pearls, in or near the edge, some saying between the mantle and the shell, others implying a position (obscurely expressed) between the mantle and the gills; 39 state that the pearls are chiefly found at the posterior end of the shell ("thin end," "sharp end," "small end," "tail end," "point," etc.), either "in" or "under" the mantle, or between it and the shell, as before. Four give little sketches to illustrate this statement (Kansas, Tennessee, and Wisconsin). Several refer to them as occasionally found in various other parts of the body, "in the meat," etc. Three papers (Indiana and Tennessee) speak of them as covered with or "incased in" a soft transparent substance; and two refer to pearls as sometimes imbedded in the shell (Wisconsin) or growing so as to "form a socket" in it (Iowa); this fact is well known, though of rare occurrence.

Frequent allusion is also made to pearls attached to the valves of the shell, or flattened on one side against them, forming "button pearls," but rarely of much value.

A peculiar statement is made in a New York paper in connection with this and the preceding question. The writer believes that pearls originate from sand grains taken in at the mouth, passing into and through the intestines, and lodging in the outer edges of the mantle, there causing irritation. Here the larger ones remain, while very small ones "pass on and go into a white substance, which I have called the pearl bag."

It is evident from these accounts that there is no proper reason for the wholesale destruction of Unios that has been practiced in many parts of this country, where the pearl-hunting "fever" has extended. Nearly all pearls of any value lie near the edge of the shell, and their presence could readily be ascertained by the use of the little instruments employed by pearl-seekers in the rivers of Scotland and Germany, and the shells not bearing pearls be returned to the water without injury, to propagate their species and, perhaps, themselves produce pearls in succeeding years.

The answers to question 14, as to the sizes, shapes, and colors of pearls found, are full, varied, and interesting. Nearly all of the papers reply to the inquiries more or less, so that the list of answers numbers 122, more than under any other head; although a good many of them are indefinite, and many speak only of some one or two of the points covered by the question.

As to the sizes, some of the responses are given by dimension and others by weight. Among much variety there is a fairly general result expressed to the effect that the maximum size for round or shapely pearls is about half an inch in diameter and about 80 grains in weight. Of course, they range downward to very small sizes, sometimes called "seed pearls," and often compared to pin-heads, bird-shot, mustard-seed, etc., and many of the papers assign much lower limits than half an inch for the maximum size. Of the papers that describe the larger sizes, several say half an inch, five-eighths, seven-sixteenths, etc., and others refer to a bullet, a marble, a large buck-shot, and the like, for comparison. A few even exceed these statements, one paper saying that pearls range from the size of bird-shot to 90 grains and even 100 grains (Tennessee); another (Texas) saying that round pearls are found larger than a buckshot, and button-shaped up to the size of a quarter dollar and "up to one inch" (Tennessee), while the Ohio paper refers to the irregular "wing pearls" as in some cases over 2 inches long. About one-fourth of the papers are indefinite, saying that the pearls are of "all" or "various" sizes, shapes, and colors, with no specific data.

As to form, there is a very general agreement in describing the ordinary forms of pearls under various designations. The usual terms employed are round, button-shaped, and pear-shaped. Other descriptions are oval, half-round, biscuit-shaped, egg-shaped, etc. Many refer to rough and irregular pearls, while others omit these as having little or no value, and hence evidently not regarded as worth mentioning. Several speak of the spherical pearls as most valued, then the hemispherical, and then the oval. All this, of course, is familiar.

In regard to color the answers are interesting, as showing the peculiar feature of Unio pearls—their wonderful variety of tint. Many papers merely say that they are of "all colors," "various," etc., but three-fourths of them, either under this head or the next, specify certain colors as most frequent, most prized, rare, etc. In 89 of

these, some of which enumerate a variety of tints, the following colors are mentioned, giving a fair idea of their relative frequency:

| | | | | | |
|---|---|---|---|---|---|
| White | 61 | Yellow | 10 | Maroon | 1 |
| Pink | 53 | Green | 5 | Copper | 1 |
| Purple | 29 | Steel | 5 | Silver | 1 |
| Black | 23 | Wine | 3 | Lead | 1 |
| Blue | 21 | Lavender | 3 | Cherry | 1 |
| Red | 16 | Brown | 3 | Salmon | 1 |
| Gold | 12 | Gray | 3 | Rose | 1 |
| Bronze | 10 | Ruby | 2 | Slate | 1 |

Of these, copper, cherry, maroon, and ruby colors may be referred to red, and, perhaps, in some cases wine color also; gray, steel, and steel-gray belong together; also, bronze and brown; and rose will fall under pink. Yellow may be placed with gold, and probably wine-color; all these last are presumably from the beautiful *Unio dromas*, the only species, or at least the only frequent one, that presents a yellow or golden nacre in a portion of its interior. The frequent reference to blue is surprising, especially from the terms used by several in characterizing the shade. Six speak of sky-blue, four of steel-blue, one of lead-blue, and one of peacock-blue (Wisconsin). One Wisconsin paper also refers to peacock-green as especially valuable, as also lavender. A few allude to the varying degrees of translucency notable in Unio pearls, referring to some as "clear," to others as "milky," and as "bone white" (opaque). One (Tennessee) speaks of them as occasionally "clear as crystal." Only two make any discriminations as to the occurrence of different colors, other than their comparative frequency or rarity. Several say that they are of various colors, according to the shells whence they are taken, and a Tennessee paper specifies that white ones come from the "yellow" mussel and steel-gray ones from the black.

The impression produced by reading this account is very strong as to the peculiar interest and value of the Unio fauna of the Mississippi basin, in reference to this production of many-colored pearls and the importance of preserving it from the reckless extinction which is threatened by the present rude and wholesale methods of pearl-hunting, in which the shells are destroyed by thousands, for want of some simple and judicious process, such as older countries have devised and applied.

The responses to question 15 are a good deal intermingled with those to question 17, and, so far as they give actual values or prices, have been incorporated in the summing up of the answers to that inquiry. Question 15 properly deals only with relative values of different sizes, shapes, and colors; and therefore these points alone have been considered in drawing up a summary of results. Many of the answers are extremely general, referring only to the fact that values vary according to size and quality; others give simply prices, which, as above stated, are included in the report on question 17. Of 96 papers responding, 61 give more or less data belonging strictly to the question, 37 of which refer to the shape chiefly, and 33 to the color, several to both and to other points of quality.

So far as shape is concerned, nearly all these agree in giving the first place of value to spherical pearls, then to hemispherical and "button-shaped," then to oval and pear-shaped. Several speak of the small and "seed" pearls as of practically no value. One gives the "biscuit" pearl as the most prized (Tennessee); this of course arises from some local circumstance. A Tennessee paper gives a valuable statement to the effect that, compared with a spherical pearl taken as unity, a "button-shaped" one of equal size and quality is worth about two-thirds, and a "pear-shaped" pearl somewhat less. A Tennessee correspondent states that rare-colored pearls are twice

the value of white, and that a 20-grain pearl is worth five times one of 10 grains. Three papers (Arkansas, New York, and Tennessee) state that one-eighth inch in diameter is about the lowest limit for salable pearls.

As to quality, several answers affirm that (of course) only the pearls that are "clear" or "brilliant" have any market value.

In color, the responses vary a good deal, and it is difficult to derive any general agreement, from the fact that while several mention two or three colors as especially prized, only a few specify which of them is the most valued. Of the 33 papers that report, 10 specify pink as either first, or among the first, in estimation; 4 refer to red, 2 as the most valued; 6 to black, 3 rating it as the best, and 4 to yellow or gold color; while, singularly enough, another paper (Tennessee) states particularly that there is no sale for yellow or black; 5 refer to blue, 2 of them rating this color as first and 2 as second, with pink first. Other colors especially named are lavender (Wisconsin), purple, steel-gray, white, and peacock green (Wisconsin).

Evidently the prevalence of certain species in certain districts, the accidents of pearl discovery here or there, and a variety of local and temporary conditions, must enter into such estimates, and would doubtless yield different results in different years or series of years.

Question 16, as to the "markets for pearls," was answered in 98 papers, the rest being indefinite or not responding at all. Out of these, 92 specify New York, 43 mentioning no other, and 47 adding one or several more. Of other places, Chicago comes next, being specified in 16 papers (Wisconsin, Iowa, Tennessee, Alabama, and Texas); then Philadelphia in 14 (one New York and the rest Tennessee); and next Cincinnati in 10 (Tennessee 8 and Texas 2); Milwaukee is reported in 8 (Illinois, Iowa, Kansas, Wisconsin); Nashville in 5 (Kentucky and Tennessee); St. Louis in 4 (Arkansas and Tennessee, each 2); and Louisville in 3 (Tennessee). Two papers mention Boston (Iowa and Tennessee); 2 Atlanta, 2 Carthage, and 2 Smithville (all Tennessee), and 1 each the following places: Washington (New York); Memphis, Knoxville, Murfreesboro, Tenn.; Elgin, Ill.; Asheville, N. C.; and Jersey City, N. J. (all Tennessee). Several make general statements as to "any large city," or include London, Paris, etc., from merely public repute. Several specify firms or dealers by name, in New York, Milwaukee, Philadelphia, etc. A Texas paper reports some pearls as sold in "Old Mexico."

Question 17, as to the prices obtained for pearls, has been answered more or less in 86 papers. Of these, 18 are uncertain or indefinite, merely saying that prices vary greatly according to size and quality, etc. The remaining 67 give figures which, however, are extremely diverse and can hardly be analyzed or tabulated with any definite result. This condition arises partly from the different methods of stating the values. Some give simply maximum and minimum prices, obtained or reported, without specifying size, color, or quality; others give prices for only certain kinds and sizes, and others again report the values by weight. Some also include the very small pearls, and others confine their account evidently to those that are marketable singly. From this varied mass of data only a few general statements can be deduced.

Tennessee and Wisconsin are the only States that report any very high prices, save in a few cases from Texas, Arkansas, Indiana, and Iowa. The small pearls—those less than a tenth of an inch—are sold in lots for a few cents apiece. The Florida paper reports selling 16, of one-eighth of an inch, for $5, an average value of a little over 30 cents; a Maryland paper mentions a brilliant one of the same size as bring-

ing $1; and a New York circular states that a pink one of that size is worth $5. Most of the little ones, however, are averaged at 5 or 10 cents in quantity. From these lower limits the values rise with great rapidity as the sizes increase, till single pearls reach to hundreds of dollars, and in some cases thousands. The limits reported range all the way from a maximum of a few cents to $1,000 (Tennessee, 5 papers); $2,000 (Indiana and Tennessee); $3,500 (Tennessee); $8,000 (Wisconsin), and even $10,000 (Tennessee, 2 papers); but no other States report anything above $300 (Iowa), and $250 (Texas). The estimated values per grain, either given in the papers or calculated from prices mentioned for pearls of specified weight, range from $1 to $75 (Wisconsin), and even $100 (Tennessee and Texas), but rarely exceed $15 or $20. In these extreme cases just mentioned the pearls must have been overvalued. Numerous cases occur where pearls have sold locally for many times more than they were worth.

To consider a few of the most definite statements, the first undoubtedly belongs to the remarkable "sky-blue" pearl from Caney Fork, Tennessee, which was sold for $950, and subsequently brought $3,300 in London. The same papers (Tennessee) that refer to this, also state that the adjacent Cumberland River, into which Caney Fork flows, has produced no pearls of more than $25 in value, though both streams have been very largely searched. One Tennessee paper reports a round pink pearl as having brought $650; another, which mentions $1,000 as a maximum value, adds that 30 cents and $700 are the actual limits of price obtained at that place. A Wisconsin paper states that $30 a grain is the highest price obtained by the writer. One response (Tennessee) gives $12 as the value of an 8-grain pearl of good quality; if pink, however, it is $18, and if yellow, $20—illustrating the differences in value for color; another (Tennessee) mentions $20 as paid in New York for a fine pearl of 6 grains, and $300 for one of 31½ grains; and another (Tennessee) gives $500 as the value of a pearl of 40 to 50 grains.

One paper from Iowa states that the finder generally gets from one-tenth to one-fourth the value of the pearl. Two Tennessee papers refer to the business as far from profitable, one saying that it does not realize an average of a dollar a day, and another that the writer thinks of giving it up as not worth while at the prices obtained.

Question 18, as to the method of taking the shells, is answered in 105 papers. Of these a number say merely that they are gathered with the hands, while 40 mention or describe some form of instrument as used in the deeper water. A Kansas paper states that the method is to pick them up along bars, etc., but the usual process indicated is to wade into the stream and take the shells from the bottom by hand, sometimes feeling for them and detaching them with the feet. In some cases a scoop or shovel is used. They are then thrown into a boat, canoe, or floating tub and taken ashore. In deeper water several speak of diving for them, but generally some form of rake or tongs must be employed—of course, with boats. Various descriptions are given, several mentioning simply a rake, "clam rake," or "mussel rake," others saying "oyster forks" or (Illinois) "a 6-tined fork bent in rake shape." This method is the principal one reported in Wisconsin, and an account is given of "rakes," made for the purpose, about 20 inches long, with 6-inch teeth, "and a wire netting on the other side to hold the mussels when raked up" (Wisconsin), and of a "garden rake with a wire basket back of the teeth, and others, similar but heavier, made by a blacksmith" (Wisconsin); and again (Iowa), a garden rake is mentioned "for sounding the bottom and driving away the mud turtles." Another description is "a rake in the shape of

a pitchfork," with five or six prongs a foot long and a handle 5 or 6 feet in length (Tennessee). Massachusetts reports "a wire dredge."

Several speak of "grubs" and "grabs," and of tongs "like a blacksmith's, only longer" (New York); and a peculiar combination is described and sketched, in a paper from New York, as "a rake with springs, which seize the clam." Two Tennessee papers allude to other methods, one describing a straight rod with a sharp thin piece of iron on the end, which is "pushed into the crevice of the mussel," the valves evidently then closing upon the intruder with such force as to allow the shell to be drawn up thereby, and the other speaking of a "spike," which may be used to a depth of 10 feet—probably the same process; both of these are reported as available only in quite clear water, obviously. Another New York paper makes an interesting reference to the use of the "water telescope," as a box with a glass in the bottom. The deep-water gathering is of course conducted with the aid of boats or skiffs, which are brought to the shore when filled; or in some cases, it would seem, the shells are opened and examined in the boat, though this is not positively stated.

Question 19, as to the apparatus used in opening the shells for examination, received 102 answers. Nearly all describe some form of knife, many referring to the common kinds by name, "case knife," "pocket-knife," "table-knife," "jack-knife," etc., or by describing it as "a short, stout knife," or more frequently "a long knife," "thin-bladed knife," etc. A Maryland paper specifies "an oyster-knife." A hammer, a hatchet, a long-bladed dirk, and "anything with a point" are also mentioned, alone or in connection with a knife. A few describe the method, one or two speaking of cutting through at the hinge, one or two of cutting the adductor muscles, whereupon the valves open. A paper from New York says: "Cut the forward muscle (anterior adductor) and then pry open until the finger can be inserted."

It will at once be seen that the methods are the rudest and simplest, and involve the destruction of every mussel that is examined for pearls, whether yielding any or not. No instance is reported of any use or knowledge of the partially opening tools employed in Scotland and Germany.

Question 20, as to the mode of extracting the pearls, when found, received 93 answers. A large proportion of these are very general, merely saying "by hand," "with the fingers," etc.; but about one-third give more or less description of the process. When the shell has been opened, the pearls, if loose and near the edge, may be readily seen, and sometimes even drop out. These are of course easily taken out with the thumb and finger, or, if small, with tweezers (Arkansas), or on the point of a knife (Tennessee). If more embedded in the mantle and gills, they are detected by feeling for them, passing or rubbing the thumb or finger along and around each valve and about the region of the hinge. The pearls may then be pressed or squeezed out "like the seed out of a cherry" (Tennessee); but if attached to the shell, must be removed with a pair of nippers (Iowa) or a hammer (Tennessee). Care is required in opening not to scratch or injure the pearl (Wisconsin). A few describe different methods; thus an Arkansas paper speaks of breaking shells, and a Florida paper tells of piling the mussels in a dry place to decay and finding the pearls in the emptied shells later. This method is evidently practicable only where little "pearl-hunting" is generally carried on, and where the pile of shells would not be liable to inspection and search by other parties than the original gatherers.

Question 21, concerning the treatment of pearls when found, received definite answers in only 78 papers, which in some respects show considerable diversity of

usage. The pearls are first thoroughly washed, to remove all adhering animal matter, and two papers speak of using alcohol to complete the cleansing. After this the essential point in keeping or carrying them is to prevent injury to the surface from friction; and the majority of those who describe what is done tell of wrapping in cotton (20) or soft paper (12), cloth, flannel, or silk, several speaking of drying them, or keeping them dry. But others would keep them in a liquid, six specifying a bottle of water, and one (Wisconsin) sweet oil or coal oil. Several speak of putting them into a bottle, but with no account of its contents, or whether even dry, though an Indiana writer mentions cotton in a bottle, and a Tennessee correspondent a vial with lint; hence in the cases just referred to it is impossible to judge as to the probable meaning. Three papers mention keeping pearls in starch, one (Tennessee) "in Irish potato," and one (Tennessee) in powdered magnesia. The effect of sunlight is curiously alluded to, five papers (Maryland, New York, and Tennessee) stating that the pearls should be carefully kept from it, and one (New York) that they should be kept in it.

Eight Tennessee papers make interesting references to "peeling" dull and unpromising pearls, merely saying that this is sometimes done "with a sharp knife" and a nice pearl obtained thereby; alcohol, whiting, chamois leather, etc., are said to be used to produce a lustrous surface. Three other papers allude to polishing or cleaning pearls (Tennessee), one specifying that it is done "with Irish potato." Two papers say nothing under this head of treatment, save that there is no way to improve upon nature. Here evidently the purport of the question was not clearly understood.

The answers to question 22, as to what, if any, use or disposal is made of the shells after being examined for pearls and the animals destroyed, give a painful record of the utter waste of an enormous amount of material useful and beautiful for many purposes in the arts. The question is answered in 95 papers, with a melancholy uniformity. In only 17 of them is there any suggestion of utilization of the shells, and in only 1 of the use of the animals other than as fish bait, manure, or food for hogs.

Thirty-two answers say simply that there is no use made of them or that they are "wasted" or "thrown away"; 13 say that they are thrown in the water, and 8 add that the fish eat them, and also the muskrats and turtles; 9 speak of their being used for fish-bait, 10 for feeding hogs or poultry, and 2 for manure. Several merely say that they are left on the banks or shoals for rats, minks, and crows to dispose of.

A paper from Iowa states that the shells are utilized for button-making and that some people use the animal for soup. The actual use of the shells for buttons is also referred to in 7 papers (Iowa, Tennessee, and Wisconsin) and their possible value for that purpose is noted in 4 other papers, though they are not so used as yet. (See pp. 425–426.) A Wisconsin paper says that a few are polished for ornamental purposes; other circulars (Wisconsin and Tennessee) contain similar statements, adding that they are also used to pave garden walks and sometimes burned for lime. This latter use, for lime, is referred to also by 3 Tennessee papers as actual or possible, and 1 says that they might be "ground to cement," and 1 from Wisconsin notes that some are ground up for poultry.

On the other hand, an Iowa writer states that "very few pearls are found in the best button shells" and one in Tennessee says that the shells are too brittle for buttons.

When it is remembered that the native tribes of both North and South America made large use of the river mussels as an article of food, as also some of the soldiers

during the late civil war, it seems extraordinary that only one instance of any attempt so to utilize them should appear in these accounts; and it is very remarkable that the shells, so capable of being wrought and polished into an immense variety of beautiful objects of ornamental art, should be almost uniformly thrown away and wasted.

Question 23, as to the principal occupations of the pearl-hunters, is answered in 84 papers. Of these, 17 say merely that their occupations are various, or that people of all callings are included. The remaining 67 papers state, more or less definitely, as follows: Farmers and farm-hands, 35; laborers, 12; fishermen, 12; and as making pearl-hunting a regular business, 8. Three papers speak of "loafers," and one or two each specify as follows: Stockmen, hunters, trappers, tradesmen, roustabouts, boys, and negroes. One refers to women and children, and the Maryland papers to oystermen. The term "laborers," as used in these answers, probably means in most cases farm-laborers, as stated in a few instances; and the indication is that two-thirds of the pearl-hunting is done by agricultural people, who search the streams when not otherwise occupied, "in off times," "fall," or "late summer," as several of the papers say. Fishermen naturally often combine pearl-hunting with their ordinary calling, and unoccupied persons of all kinds turn to it as affording a possible resource instead or in default of regular employment. The references to negroes, only mentioned as such in two (Tennessee) papers, are curiously few; and it seems that they, for some reason not apparent, engage but little in the business. Many of the farm-hands and fishermen, however, may be colored, although it is not so stated.[1]

Questions 24 and 25, as to statistics of the pearl fishery during the year previous to the report and former years, respectively, received so few answers that no definite results can be gathered from them. The few data that are given would afford no estimate of the extent of the industry or of the actual commercial value of its product.

Question 26, as to when the pearl industry was of most importance, has received more or less definite answers in about two-thirds of the papers. The others either fail to make any statement or employ terms so vague as to be of no significance. A number answer by giving the time of year or stage of water, not understanding the purport of the inquiry, and a few say that the yield does not vary much from year to year. Of 80 papers that give definite or approximate dates for the time of chief activity, only 27 mention or include the recent years (i. e., 1894–1897, when the reports were written), though several more do so by implication, using phrases like "since 1890," or "not before 1891." Several state that the yield has diminished within a few seasons past; 41 papers specify years between 1890 and 1897, inclusive, and 19 between 1880 and 1890. One Tennessee paper gives 1878–1884; an Iowa paper gives 1878–1890, and the Ohio paper says 1860 to 1890. The 8 Wisconsin papers give years from 1889 to 1892, two referring to thousands of dollars' worth of pearls as taken in 1890, which seems to have been the year of maximum yield. The Texas dates are rather earlier, two papers giving 1886 and 1880–1886, respectively, though one says 1893. For Arkansas, Florida, Illinois, Indiana, Maryland, and Pennsylvania the dates all range between 1890 and 1894, and chiefly since 1892, the search for Unio pearls having apparently been taken up since and in consequence of the great discoveries in Wisconsin, although in some cases it had a strictly local and independent origin, as shown

[1] It is of some interest to note the fact that in Iowa two well-known pearl-hunters are Indians: On-a-wat at Montour and John Mus-ke-mo at Nonotaker, Tama County. In their cases may perhaps be seen the continuance, to the present day, of an ancestral habit, which is proved by the abundance of Unio pearls in ancient mounds and by the traditions of the early explorers of North America from the time of DeSoto down.

by answers under the next head. In Tennessee it has been carried on at different points since 1880 and even 1878.

The twenty-seventh inquiry, concerning the history, origin, and growth of the pearl-fishing, is answered in less than one-fourth of the papers; only 35 reply to it at all, and 5 of these are entirely indefinite. Several merely give the year when pearl-hunting began, with no incidents or data otherwise. A few allude to it as diminishing (Tennessee); or, when of late origin, increasing (Tennessee and Iowa). The circumstances connected with the origin of the pearl industry, as reported in a few of the papers, are of considerable interest, and may be put on record as follows: Arkansas reports that in 1889 two pearls were found in one shell. Inquiry showed that some twenty had been found from time to time previously, and the facts were then published in the newspapers. An Indiana paper states that the first interest arose from accidentally finding a valuable pearl in opening a shell. The Maryland paper refers it to a newspaper article, about 1885. Texas reports a pearl discovered in opening a mussel for bait; the crops had failed that year, and pearl-hunting was widely taken up. Three Tennessee papers date the first excitement from what is evidently the same incident, related with slight variations, that in 1880 a fishing party came from Murfreesboro, one of whom was a jeweler. He found a pearl in opening a mussel for bait, and sent it to New York, where it was sold for a handsome price. Other responses from the same State give somewhat similar accounts, probably of the same circumstance. A Wisconsin paper states that in 1890 a Norwegian disclosed to a few persons the fact that he had been finding pearls for some years before. An interesting and isolated statement is made in a Tennessee paper that the matter was "brought into notice of the people here (Clinton, Tenn.) by button manufacturers having the shells gathered here," and that it has been kept up by "hard times."

Question 28, as to the exhaustion of the mussel-beds, its causes, and its rapidity, has called forth a very suggestive body of replies in 77 papers. The other papers make no response, or none that is at all definite. Ten papers report extermination of the shells, either actual or imminent, within a very few years past; 23 speak of rapid diminution in their numbers; 23 of decrease as noticed and in progress; 13 are uncertain, or report little or no change; 6 describe them as abundant or "inexhaustible," and 5 refer to partial recovery or replenishment after reduction. In 56 out of 77 papers, therefore, or approximately three-fourths, the process of exhaustion is recorded, at times already complete. Of these, 29 state the cause as pearl-hunting, mainly or wholly, and 10 papers refer to other agencies—2 or 3 each to high or low water, deposits of sand or mud, ice, boats, hogs, and rats. Of the 7 answers from Wisconsin, where so many pearls of remarkable beauty were found in the early "nineties," 5 report the shells as nearly or entirely exhausted, and 2 refer to rapid reduction, due to ignorant and careless persons taking the small and young shells as well as those more likely to contain pearls. A Tennessee paper alludes to the same reckless habit, and estimates the shells remaining as about 5 per cent only of the number in former years. The destruction of the young shells is also mentioned in Indiana. In New York it is stated that a good pearl-fisher can "clean out" a bed of 500 shells in a day; the Ohio paper speaks of hundreds being opened daily, and an Iowa writer states that the river will be exhausted in two years. Of those that speak of little change, several remark that not much is known or done in regard to pearls at their localities. Of the 4 that allude to recovery, one (Tennessee) says that the beds are cleared out about every two years and renewed in four; another (Tennessee) says that they

become exhausted yearly and re-bed in one or two years; still another (Tennessee) states that the shells return every year, but in less numbers; and one (Texas) reports that many beds that had been worked out are recovering, through the growth of the young shells that were left unmolested.

The twenty-ninth inquiry, as to whether exhausted beds recover and in what time, is closely connected with the preceding one. It is unanswered in 25 of the papers and 9 others report no knowledge or opinion on the subject. Eighty-eight replies are given, of which several are indefinite and conjectural. Out of about 80 papers, therefore, or two thirds of the whole, 26 report the belief that the beds are replenished from year to year; 8 in one or two years; 4 in two or three years, and 4 in four years; 6 name periods between four and eight years and 7 between eight and twelve years; 1 gives twenty years; 1 gives twenty-five, and 2 estimate the recovery as requiring a century or more; 4 papers say that many years are necessary; 6 say "a few" or "soon"; 4 report no exhaustion as noticed, and 6 report no recovery. Several papers are indefinite or uncertain. Two of those that give estimated dates for recovery do so with an expression of doubt ("if at all," "if ever") as to whether it really occurs. A Tennessee paper says that the shells return each year, but in less numbers. As it is customary, more or less, to leave the young and small shells, the question resolves itself largely into two, viz, how far they have been carefully spared and how long it takes them to attain their growth. This last probably differs in different species, as is intimated in some of the answers, and it may also be influenced by various external conditions. Another Tennessee paper estimates the recovery as slow, from the fact, previously brought out very markedly, that the young shells are those that are most exposed to all natural enemies and accidents. A New York paper, which thinks that there is no recovery, states that few young shells are found. A Texas paper says that young shells are found in two years, but contain no pearls, and another from the same State says that many beds are recovering by the growth of the young that were left before. On the other hand an Indiana paper states that when a bed has been worked out plenty are found the next season, and an Iowa paper reports young shells abundant everywhere. One of the papers from Tennessee probably gives a very fair average statement, to the effect that the beds recover somewhat every season, and would, perhaps, recover entirely in a few years, if not molested.

The concluding inquiry, as to whether State protection of the beds is desirable or necessary, is answered with more or less definiteness in 97 papers, and, as might be expected on such a subject, with much diversity. Fifty-nine of the responses see no need or advantage from protection and 33 favor it. One or two fail to understand the purport of the question clearly, and some hold that while not necessary now it may be so in the future. Two or three say that it would be difficult or impracticable. A few of the answers may be referred to more particularly. Of those that do not favor protection, 2 (Michigan and New York) think it not worth while or desirable to preserve the Unios, the latter curiously remarking that "the water would be purer without them." One Tennessee writer seems to hold a similar view, saying that protection is not desirable, though it is necessary to the preservation of the shells; another, failing to appreciate the question involved, opposes protection "because pearls bring in a great deal of money, and the mussels are of no use." Two or three think that the shells are inexhaustible and in no danger of extinction. Of those that favor the suggestion, 1 from Indiana states that it would be well if no shells were taken for five years; the Ohio paper advocates it "if the mussels are to be preserved." One

paper from Tennessee alludes to the value of the shells for pearl buttons as a reason for protection, and 2 others from the same State advocate a limitation as to not opening young shells. A Texas paper expresses the belief that "it would give general satisfaction to all the land-owners on the stream on which the shells are found." This plainly alludes to the trespassing by pearl-hunters on farm lands along the streams as a source of annoyance to proprietors.

The general conclusions most clearly brought out may perhaps be summed up as follows: The shells are most abundant in swift and clear water, where the bottom is sandy or gravelly and the country rock calcareous. While still numerous in many streams, they have greatly diminished within a few years past, wherever the pearl-hunting enterprise has extended, and are at some points nearly exterminated. The pearls found are few, and those of marketable value represent the destruction of thousands of shells for every pearl obtained. No use is made of this often beautiful material, which is simply thrown away and lost, although for buttons and ornamental articles it would be admirable. The methods of gathering the shells and extracting the pearls are the simplest and most primitive, and the activity of a few seasons generally exhausts the beds.

This state of affairs is one that calls loudly for reform. The wealth of Unios that fills our rivers and streams is rapidly being destroyed by ignorant and wasteful methods of pearl-hunting, and either some form of protection is important, or, if that be not possible, a wide diffusion of information as to better methods, and particularly the introduction of the tools used in Germany for opening Unios far enough to see if there are pearls contained, without destroying the animal, which may then be returned to the water.

The whole question is curiously suggestive of the similar conditions in respect to forestry and lumbering; the apparently inexhaustible natural supply; the reckless prodigality and waste of such resources by man; the rapid diminution and impending extinction which it would require years of care and labor to restore; the foresight and remonstrance of the few and the indifference or opposition of the many, as to any limitation or protection designed to preserve the natural resources; and the ease with which they could be preserved by a few simple and intelligent modes of management once established and made familiar to the people; and the pressing importance of some such action in place of the *post nos diluvium* policy at present prevailing.

The question of legislation in such matters is always very difficult, both in procuring and enforcing any restrictions. But it would be most desirable to impose some limitations to prevent the wholesale destruction that is now carried on. Such limitations should aim to prevent the taking of young shells at any time, and establish "closed seasons" occasionally, when the Unios should have a chance to remain undisturbed. Of great importance, also, would be the description and explanation of the opening-tools that are used abroad, and the inculcation of their use upon pearl-hunters in this country, so as to avoid needless destruction.

## FRAUDULENT AND ACCIDENTAL INTERMIXTURES WITH PEARLS.

In the small lots and packages of pearls that are sent to commercial centers for purchase or valuation, quite a variety of foreign objects are found, some of which have evidently been introduced with fraudulent intent, while others have got among the pearls accidentally, and were evidently mistaken for pearls.

Among the former are regular artificial pearls, i. e., hollow beads of thin glass filled with wax or other composition; also ground pieces of pearly shell or attached pearls that have been cut from the valve and rounded and polished on the defective side—occasionally rounded and cut entirely out of the shell itself, and of no value. Frequently the round, hard lens of a fish's eye is found in parcels of pearls.

In the second class may be mentioned natural growths found in the shell resembling brown pearls; translucent, but consisting not of nacre, but of conchioline—the material of the hinge and ligament. These are sometimes handsome and lustrous, and occasionally iridescent, but, of course, are not pearls and have no commercial value.

A third class of doubtful character consists of metallic objects that sometimes strongly resemble pearls, and may have been introduced either by intention or by accident. Such are small shot and steel spheres from ball-bearings; these, when bright, look much like the darker and lighter gray pearls, respectively, and are quite frequently encountered.

## USE OF UNIOS AS FOOD.

Indications point to the use of Unios as an important article of food by the Indian tribes at the time of the discovery of the country, and occasionally by the white explorers. This practice probably prevailed for ages, in both North and South America, back to the time of the Mound-builders. It seems, however, remarkable that so little use has been made of these abundant shellfish by the whites; and the question is worthy of attention, whether we have not here a ready and valuable source of food supply throughout large areas of the country remote from the sea and its products. There seems no reason why these mollusks should not be palatable and nutritious, and such is the testimony of the few who have tried them.

While sailing down Canadian rivers on their rafts, lumbermen collect Unios for food by fastening bushes to the rear of the raft so that, when they pass through the mussel shoals where the rivers are shallow, the bushes touch, the shells close on the leaves and thin branches, holding to them securely, and at intervals the bushes are taken out and the Unios removed. In the same way we have the fact, referred to by Professor Rau, that the Unios of the Tennessee River were sometimes cooked and eaten, as a change of diet, by the soldiers of the Army of the Cumberland during the civil war, as stated by Dr. Brinton. They might even serve an important purpose in preserving life, in the case of exploring parties or travelers becoming lost in a region where other food was not procurable.

STERLING SILVER TEAPOT.

Gilt, encrusted with baroque pearls from the rivers of Tennessee. Made by Tiffany & Co. Paris Exposition, 1889.

## PEARLS AND PEARL-BEARING SHELLS IN ORNAMENTAL WORK.

Efforts to make the river mussels of Germany available in ornamental work have met with much success. In 1850 Moritz Schmerler conceived the idea of making small fancy articles of the shells themselves, and succeeded so well that the Saxon Government allowed him to take from the royal beds the shells he needed for his manufacturing business. Large numbers of pearl-shell pocketbooks and hand-satchels have been made since then. The almost faultless white and reddish tinted "rose-pearl mussels" are specially prized for this purpose, as the shell material may be cut so thin that a photograph pasted inside can be seen through the shell, conveying the appearance of being produced on the shell itself. Other manufacturers engaged in the business, and many hundred thousands of the pearl mussels are now annually used at Adorf, where the business is chiefly carried on. The principal sources of supply are brooks in Bavaria and Bohemia that are owned by private persons. Here is a suggestion as to the possibilities of our American river shells. They are now occasionally polished for ornaments, and, with their pearly iridescence and varied shades of white, cream, pink, salmon, and purple, are objects of great beauty; but thus far they are almost unknown and unused in the realm of decorative art.

Some beginnings have been made in this direction in the United States, but only enough to indicate how much might be done. At the Mammoth Cave, there have long been sold as souvenirs to visitors little pocket-books and match-safes made from cut and polished Unio shells from the adjacent Green River, and they are often exceedingly pretty articles. Very lately a leading jewelry house in New York has begun to use polished Unios for small jewel-cases; they are brilliantly pearly and when lined with velvet are well adapted for such purposes, especially as used for fresh-water pearl jewelry.

In 1893, at the World's Columbian Exposition at Chicago, a large amount of material was shown, illustrating the actual and possible uses of fresh water pearls and pearl shells, and especially of our own Unios. As these exhibits were scattered through various public and private displays in several of the buildings, it may be well to bring together here a brief summary of the whole.

At the Tiffany Pavilion in the Manufactures and Liberal Arts Building there was a collection illustrating the occurrence of pearls and the various pearl-bearing shells and mollusks—notably a series of several thousand odd-shaped and curiously formed pearls, pearl blisters, and hinge pearls from the Unios of Wisconsin, Texas, Tennessee, and Ohio. In this collection were found round, oval, oblong, and mallet-shaped Unio pearls; two pearls ingrown into one another; pearls consisting of scarcely more than a blister, others formed of a single nacreous layer with a central arc of clay, and other curious and abnormal growths of interest to the naturalist, but of little commercial value. A silver teapot incrusted with fresh-water pearls (see plate VIII), and a watch case so thickly covered with Tennessee pearls that scarcely any mounting could be seen, were striking illustrations of the adaptation of these native products to elegant work in art. There were also exhibited Unio pearls from Weymouth, Nova Scotia; seven pearls from the original find made in 1856 at Notch Brook,

near Paterson, N. J. (from the collection of Prof. D. S. Martin, of New York, where they had been since a short time after the discovery); and a small quantity of pearls taken from the altar of the Turner group of mounds, Little Miami Valley, Ohio (from the original find of Prof. Frederick W. Putnam, who obtained several bushels of them, resembling strikingly those found by Warren K. Moorehead).

There was also a large collection of various species of Unios, from the small shells to the magnificent valves measuring nearly 8 inches in length, in a series in which one valve of each specimen is polished and the other in its natural state, to show the commercial possibilities of these shells. These were principally from the Sugar River, Wisconsin; others from Texas, Tennessee, and Kentucky.

A glass jar contained a fine specimen of the fresh-water mussel *Margaritana margaritifera*, from the Botova River, in Bohemia, carefully prepared and injected, showing a pearl in place between the mantle and the shell (see plate II).

A very interesting series of mounted fresh-water pearls was shown from Wisconsin, Tennessee, Ohio, and Texas. Among these are some absolutely white, pink, and brown pearls. All those from Wisconsin are very fine, possessing a marvelous metallic luster. In the Mining Building, Bunde & Upmeyer, of Milwaukee, exhibited several hundred Unio pearls, some of them very fine, of the various colors found in the rivers of Wisconsin.

The New York State exhibit, in the gallery of the Anthropological Building, contained a superb collection of Unios, beautifully mounted and well labeled, belonging to the State cabinet. This collection embraces those of the Rev. John Walton, Shelly G. Crump, C. E. Beecher, and others. In the south gallery, forming a portion of the exhibit of Professor Ward, of Rochester, were some magnificent specimens of Unios. Superb examples of *Dipsas plicatus* Lea, from Lake Riwa and from central China, containing pearl figures of Buddha, and flat, pearl-like disks, produced by inserting between the mantle and the shell of the mollusk small tin-foil figures or disks, were shown in the folk-lore collection of G. F. Kunz and in the Ward collection in the south gallery (see pl. III), both of which are now in the Field Columbian Museum.

In the southeastern gallery of the Anthropological Building were about fifty specimens of Unios and mother-of-pearl shells with one valve of each shell polished.

One of the most interesting objects of pearl inlay was a small, round earthenware pot in the collection in the Cliff-dwellers' exhibit, just west of the Anthropological Building. In this earthen pot irregular squares of Unio shell have been inlaid in hard clay in regular layers, the clay between the pieces of pearl being about the width of the pieces themselves, and producing the effect of mosaic. This is the only object so decorated that has ever been found.

In the Swedish Building, Augusta Mollenberg, the royal court jeweler, exhibited twelve fresh-water pearls, weighing from 4 to 10 grains each, eight mounted on a chalice and two on an ecclesiastical bowl. A Norwegian jeweler exhibited several dozen pearls, white and faintly pink, from Norwegian rivers.

In the English section of the Manufactures Building, Edmund Johnson, jeweler royal of Ireland, exhibited several fresh-water pearls, weighing over 10 grains each, from Irish rivers, mounted in a brooch, in his collection of reproductions of Irish gold antiquities.

In the Mexican section, in the Fisheries Building, from the district of Jederal, with a series of marine pearl shells from the west coast of Nuevo Leon, was another series of fresh-water Unios, some measuring nearly 10 inches in length.

Valve of Unio in its natural state, and the same with "blanks" cut out from it.
"Blanks" as cut; three upper figures showing inside, three lower showing outside with more or less of the epidermis.
The same ground but not "centered" or polished.
The same centered, i. e., with the central depression made, but not the holes.
The same with the holes drilled complete.
A dozen buttons, as fastened on card for sale.

THE EVOLUTION OF A PEARL BUTTON

## UTILIZATION OF UNIO SHELLS FOR BUTTONS.

The valuable possibilities of using Unio shells in making buttons have at last attracted attention, and an important industry is developing. A correspondent of the St. Paul (Minn.) *Dispatch*, under date of November 13, 1897, gives an extended account of the shell-button manufacture at Muscatine, Iowa, where already a number of factories are in operation. No dates are specified; but the statement is made that it was begun within a few years past by Mr. Boepple, a German, who recognized the possibilities of such an industry and established a factory at Muscatine, soon employing 200 operatives, besides a number of outside people gathering shells from the Mississippi River at that point. The enterprise proved profitable, even under an unfavorable tariff, and several other factories were established; but since the recent protective legislation has gone into effect the business is increasing largely. Eleven or twelve factories are now in operation, running 300 saws and employing 1,500 people. One of these was working on double time, to fill orders for 20,000 gross of buttons for the "holiday trade" of 1897. The business is already an important element in the prosperity of the town; and as the supply of shells is enormous it is expected to increase in extent. Other works exist in Iowa, at Davenport and Sabula, and at Cedar Rapids, on the Cedar River. There are also eastern factories referred to, that cut the shells into "blanks"—i. e., unfinished disks—and send them to Muscatine to be polished and perforated.

The shells have been heretofore gathered by men and boys wading in the shallow water, and working from boats in the deeper parts with rakes provided with a wire net or basket. Now, however, one boat has been built for steam-dredging, and another is under construction. The dredge will take up a ton of shells in an hour, and the steam will be used to cook the animals and clean the shells—a process now slowly conducted in small furnaces. As the gathering can not be carried on in winter when the river is frozen, prices rise in the autumn. Several species are capable of being used, of which two are particularly mentioned; these are "nigger-head" shells, which have risen with the approach of winter from 35 cents per 100 to 70 cents, and "sand" shells, which have advanced correspondingly from $1 to $2 per 100.

If the myriads of shells destroyed by the pearl-hunters could only be gathered and sent to the factories, or if cutting-works could be established in the districts affected by the "pearling" fever, much of this fine material could be utilized. On the other hand, the development of a large demand for shells by this industry and the introduction of steam-dredges to gather them by the ton from water too deep for the pearl-hunters to deal with, threaten within a few years' time to obliterate the Unio fauna largely, if not wholly, from our waters.

Following are some statistics in regard to the pearl-button business:

*Selling price-list:* First quality: 16 line, 48 cents per gross; 18 line, 51 cents per gross; 20 line, 55 cents per gross; 22 line, 60 cents per gross; 24 line, 65 cents per gross; 23 line, 70 cents per gross.

Second quality: 16 line, 40 cents per gross; 18 line, 43 cents per gross; 20 line, 47 cents per gross; 22 line, 52 cents per gross; 24 line, 57 cents per gross; 26 line, 62 cents per gross.

Third quality: 16 line, 27 cents per gross; 18 line, 30 cents per gross; 20 line, 36 cents per gross; 22 line, 37 cents per gross; 24 line, 41 cents per gross; 26 line, 45 cents per gross.

*Prices paid sawyers:* 26 line, 10 cents per gross, sawing whole shell; 26 line, 11 cents per gross, sawing butts; 24 line, 8½ cents per gross, sawing whole shell; 24 line, 9½ cents per gross, sawing butts; 22 line, 7½ cents per gross, sawing whole shell; 20 line, 7 cents per gross, sawing whole shell; 18 line, 6 cents per gross, sawing whole shell; 16 line, 5½ cents per gross, sawing whole shell.

By whole shell reference is made to sawing all the 26-line blanks there are in the shell. A gross is 14 dozen. The extra 2 dozen are to make up for the imperfect blanks or buttons, and these are all counted by weight. By butts are meant two different lines of blanks cut from 1 shell.

*Prices paid grinders:* 1 cent facing on grinder; 1½ cents grinding one side, per gross, all sizes.

*Prices paid turners:* 24 and 26 line, 4 cents per gross; 20 and 22 line, 3½ cents; 16 and 18 line, 3 cents; scratch center, 2 cents per gross; ring center, 1½ cents.

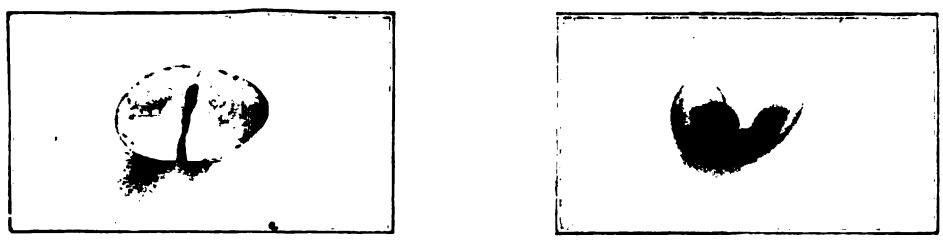
*Prices paid drillers:* 3½ cents per gross 4-hole, all sizes; 2 cents per gross 2-hole, all sizes.

*Carding:* 5 cents per gross.

The capacity of a 10-saw factory is from 800 to 1,000 gross per week. The Muscatine buttons now bring a better price than the eastern goods.

Several button companies are now fully organized, and are producing large amounts of material.

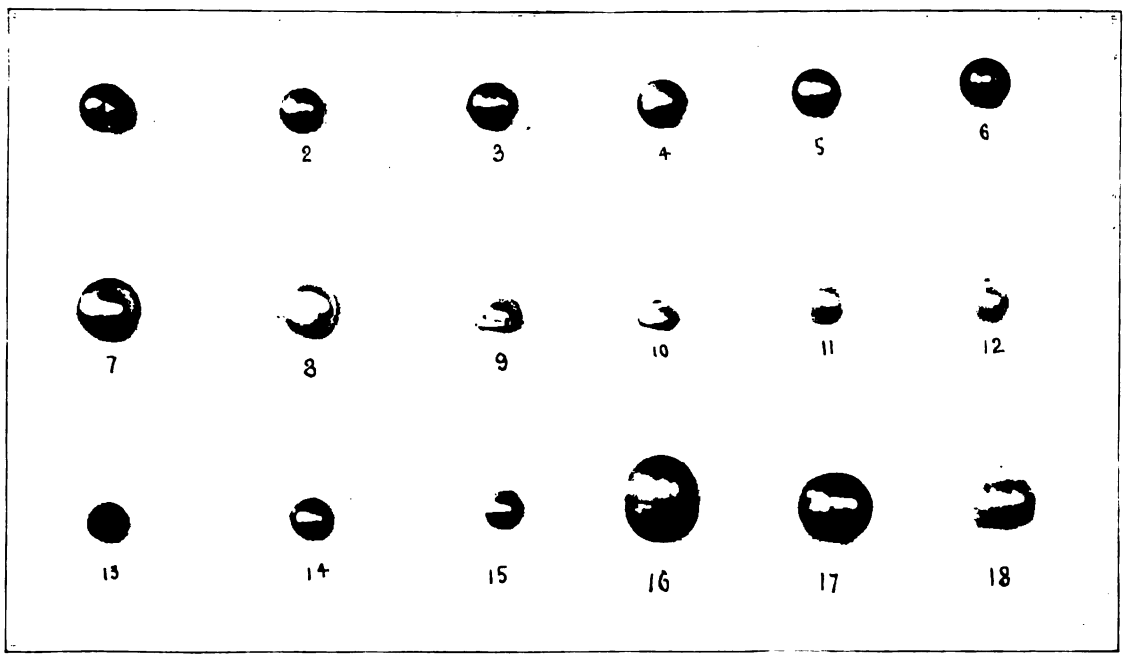
In view of the button industry, even more than of the occasional yield of pearls, the question begins to arise as to the artificial culture of Unios. Between "pearling" and dredging for button-factories, the supply, however abundant, must soon be greatly reduced, if not exhausted altogether, unless some means can be found for increasing and maintaining it. For this purpose it would seem that Unio "farming" might yet become desirable and practicable as a source of industry and of profit, more especially if carried on in connection with the insertion of figures, flags, and other forms that might find a ready sale.

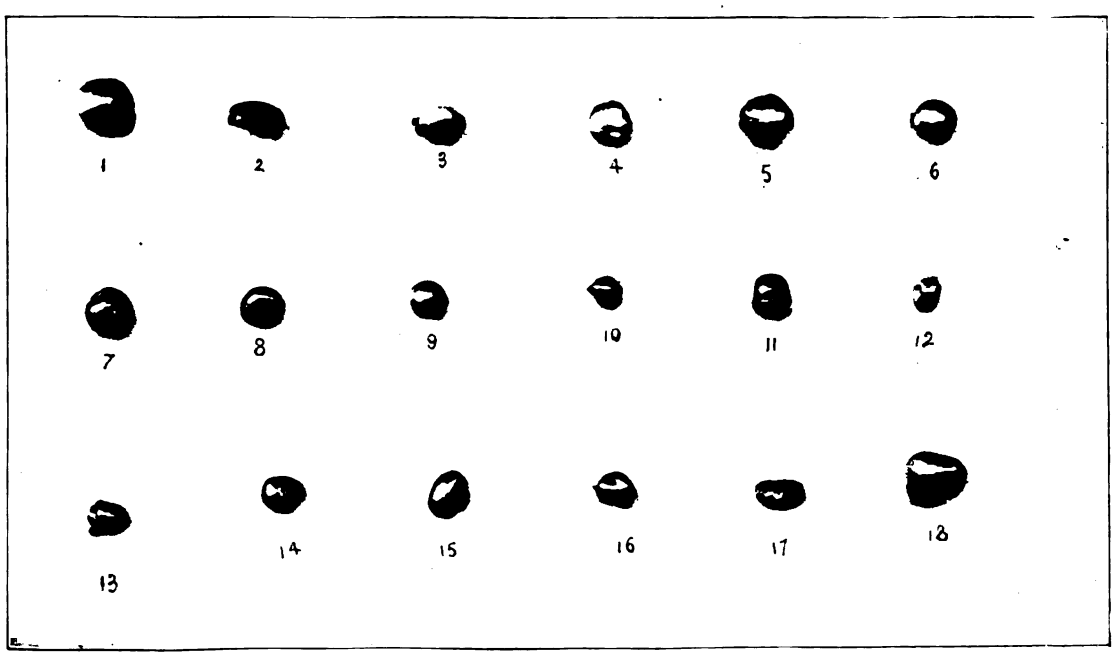


*A* *B*

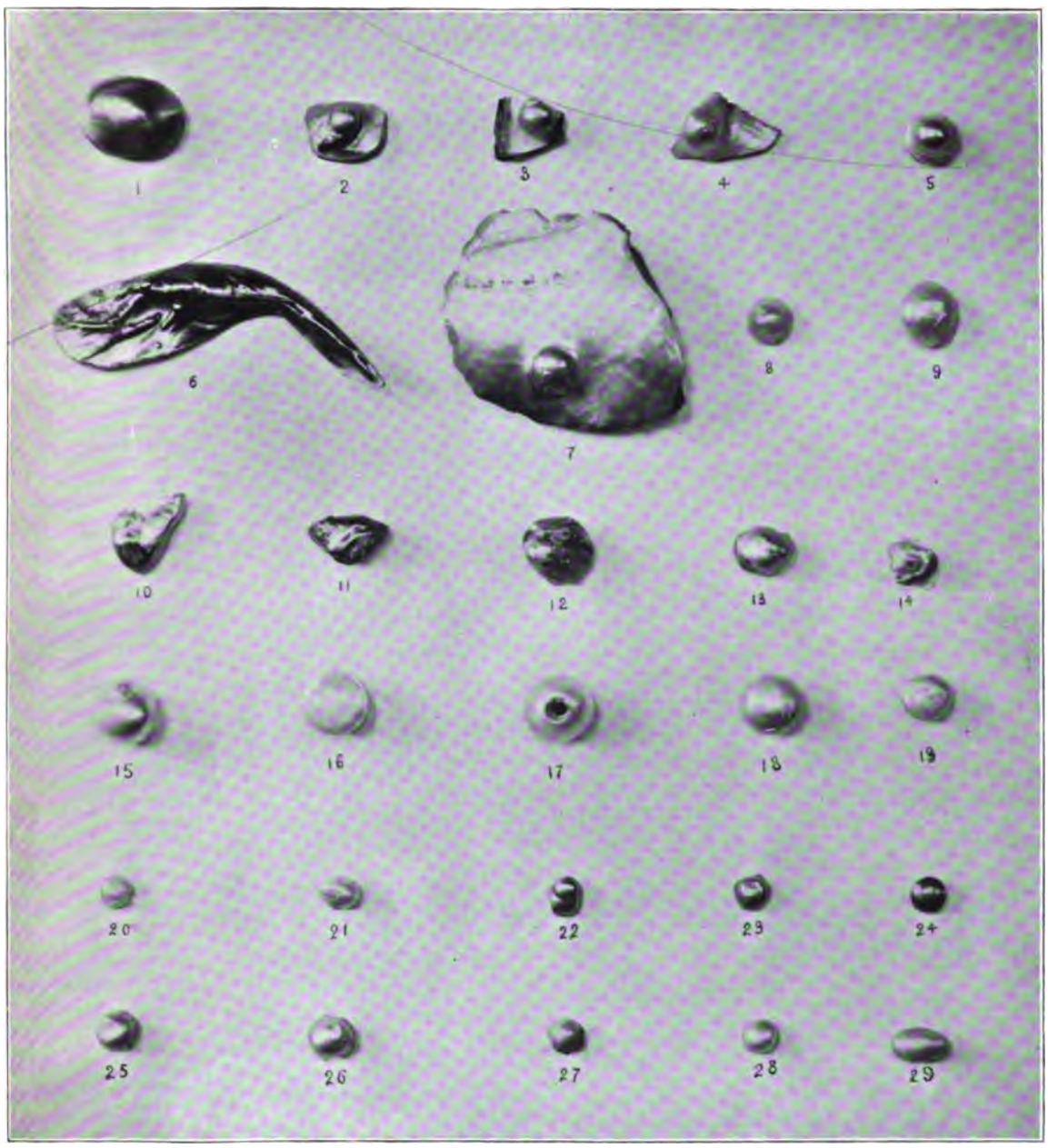
HOLLOW PEARL MADE BY CHINESE, BY SCALING OFF A LAYER FROM A LARGE OVAL PEARL AND FILLING IT WITH A COMPOSITION OF HARD WAX OR SHELLAC TO STRENGTHEN IT.

*A*, convex side; *B*, concave side, showing portion of the filling adhering along the line of the transverse crack, which revealed the deception.




IRREGULAR AND BUTTON-SHAPED PEARLS.




ENCYSTED PEARLS AND PEARLS WITH MARKED INTERIORS.

No. 1. Pearly lump from shell of Unio.

Nos 2-5, 7-9, 13. Encysted or ingrown pearls, Plate XI showing them from the inner side, Plate XII from the outer side, the pearls sometimes appearing from the exterior, through the shell (2, 3, 4), at other times not at all (7).

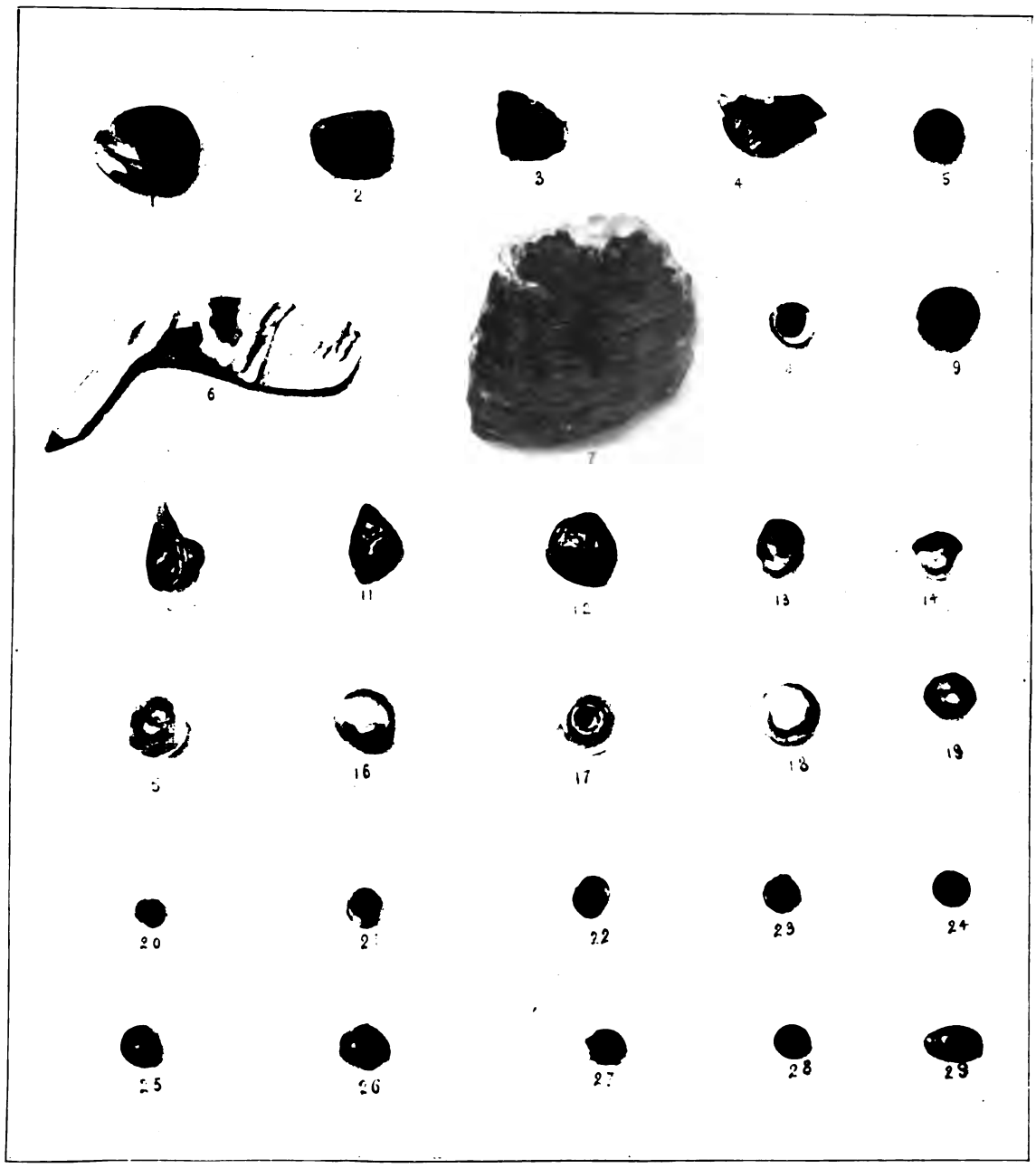
No 6 Small crayfish completely encysted. Plate XI, inner side, showing details of the animal; Plate XII, other side, faintly.

Nos. 10-12, 14-16, 18 21, 23-29. Pearls formed over some foreign matter differing in color from the nacre. Plate XI shows the upper or most perfectly coated side; Plate XII the reverse, occasionally showing the structure of the inner growth.

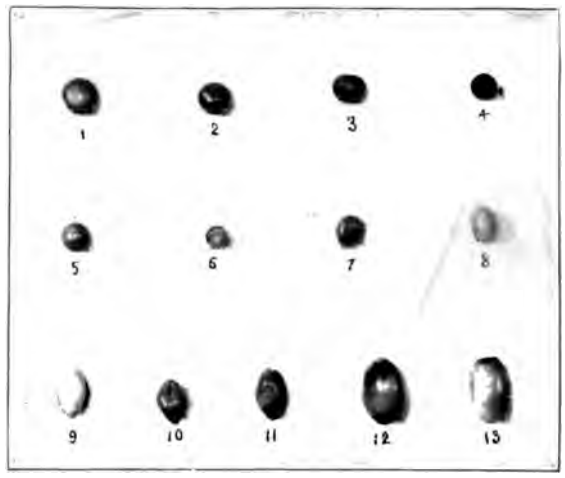
No. 17. Hollow bead-like pearl, from which the nucleus has entirely disappeared—perhaps some insect or bit of vegetable matter that has decayed, or piece of clay that has disintegrated and washed out. It can now be blown through like a whistle. Plate XII shows the concentric layers very well.

No 22. Double or notched pearl, the result of the joining and intergrowth of two pearls.

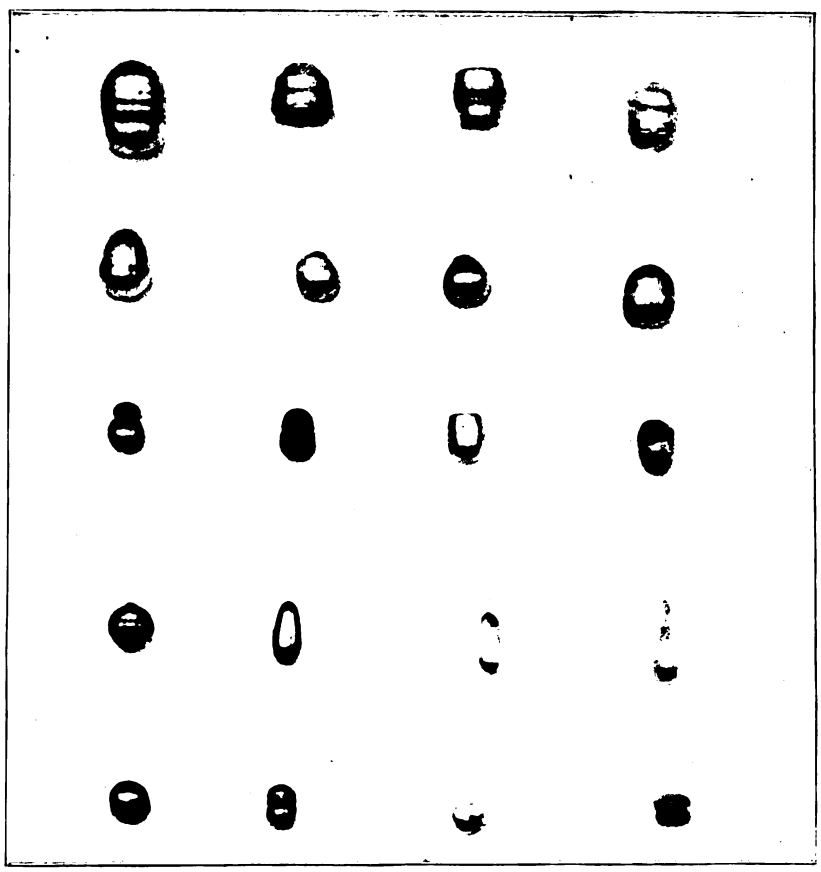
PLATE XII.




SAME AS PRECEDING PLATE, BUT SHOWING EXTERIOR SIDES.

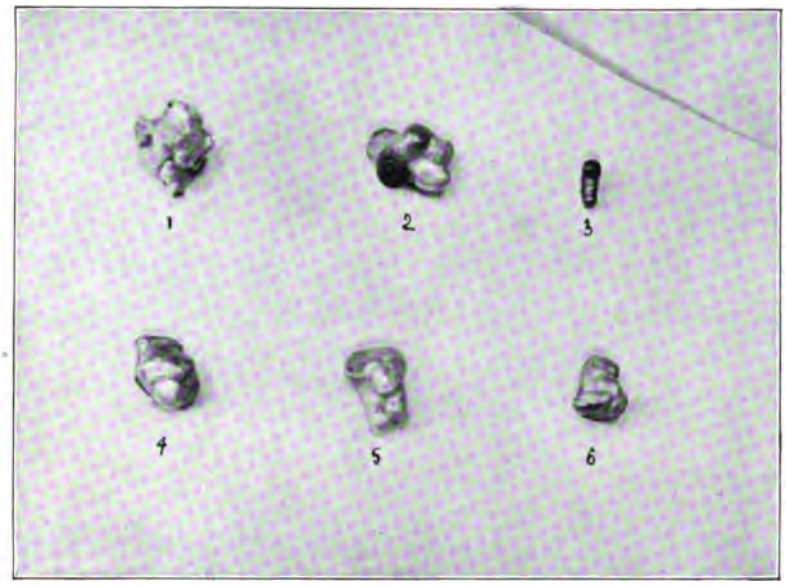



ROUND AND ELONGATED PEARLS.

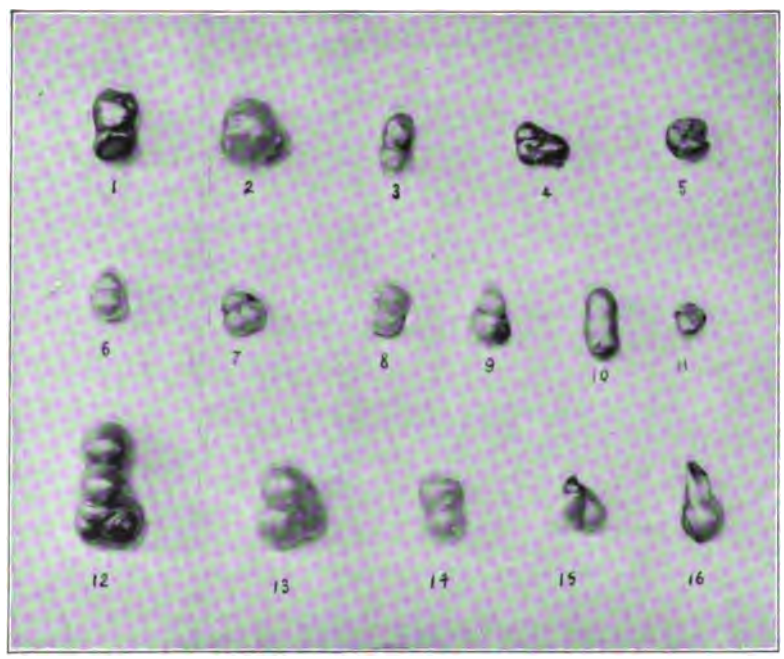


PEARLS PRESENTING THE ASPECT OF HAVING BEEN TURNED IN A LATHE, I. E., WITH ONE OR MORE REGULAR RIDGES OR FURROWS RUNNING COMPLETELY AROUND THEM.

'm these pearls may be either round, pear-shaped, club-shaped, top-shaped, or flattened like a quoit. Some of them are plainly cases of coalescence ,two left-hand figures of middle row and two central figures of bottom row; compare, also, Plate XIV, Group A, fig. 6); others may be due to a turning and rolling process which is believed by some to be constantly practiced by the animal in the case of "free" pearls.



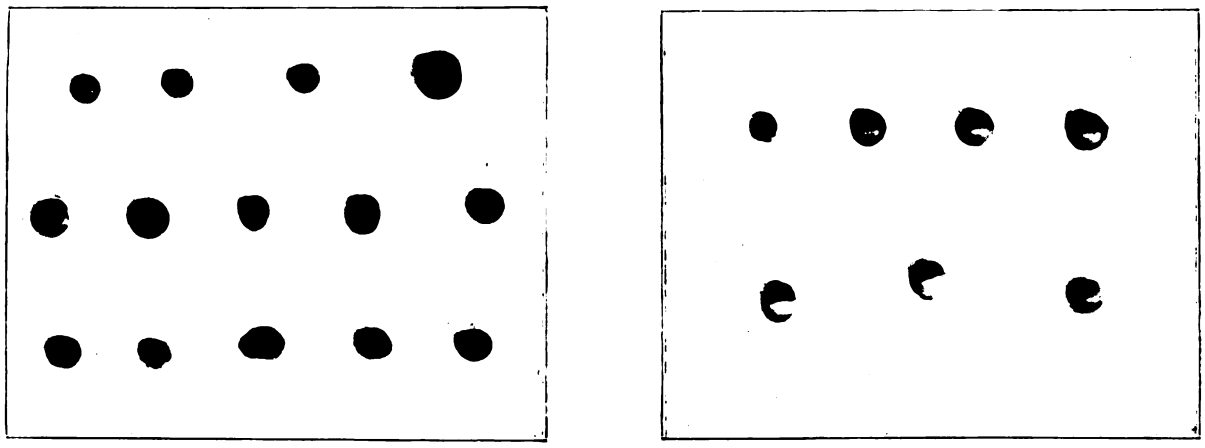

Group A.



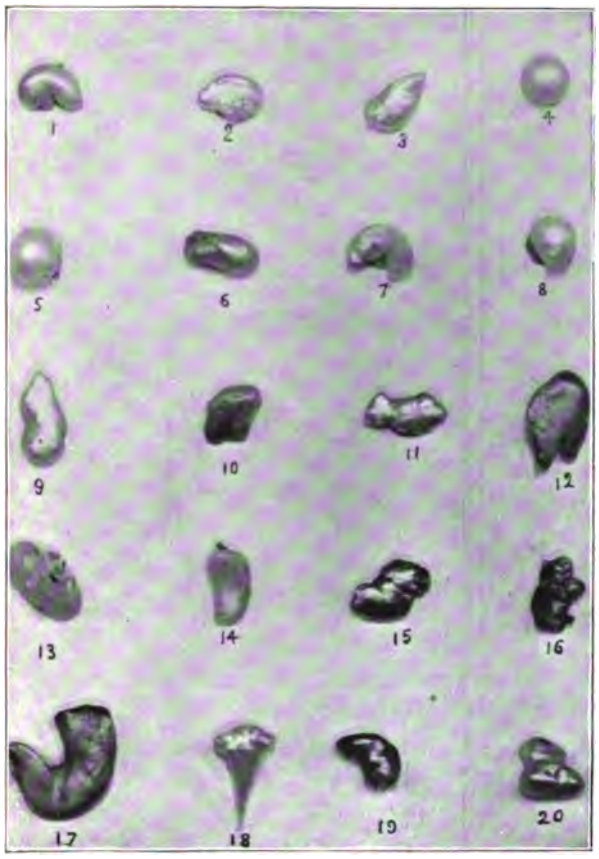

Group B.

GROUPED PEARLS, CONSISTING OF SEVERAL ORIGINALLY DISTINCT PEARLS JOINED TOGETHER AT A LATER STAGE BY A CONNECTING DEPOSIT OF NACRE.

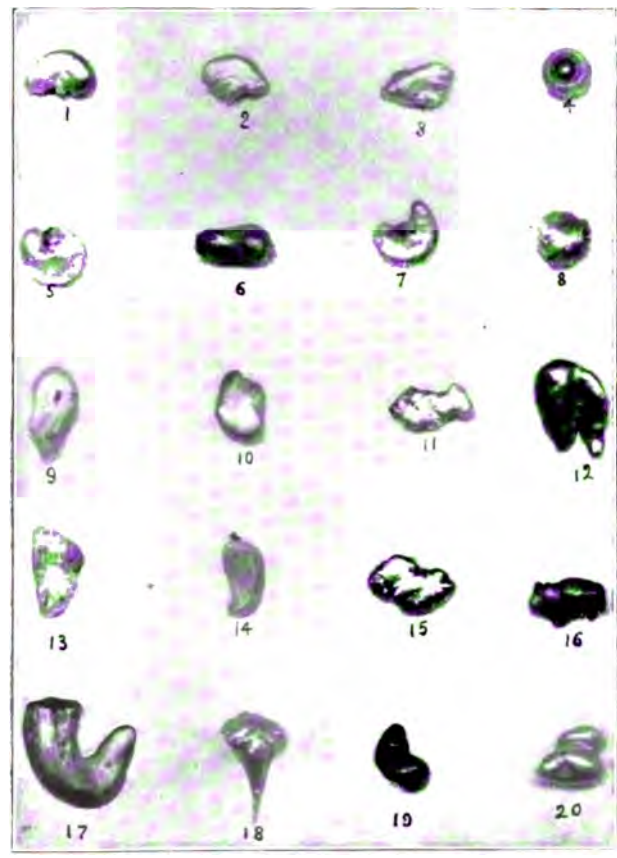
In Group A are seen many thus united, in some cases up to a dozen in number (fig. 1), and at times several in a linear series (fig. 3). In Group B are shown groups of from two to five, a beautiful triple one in fig. 7 and another in fig. 13. In fig. 6 two are joined so as to produce the "turned" appearance illustrated in Plate XIII.



WISCONSIN PEARLS. PINK, COPPER-COLORED, AND BROWN.




Group A. Top view of pearls.




Group B. Under side of same.

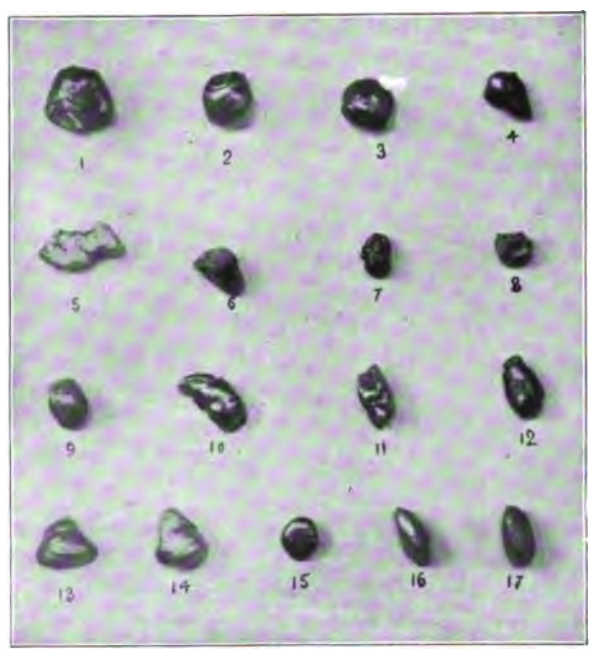
TWISTED AND RENIFORM PEARLY GROWTHS, SOME SHOWING GROUPING OR COALESCENCE.

No. 4. With central nucleus, the layers finely shown in Group B.

Nos 5, 7 Plain spirals. Nos. 15, 19. Elongated spirals. Nos 12, 20. Well-marked coalescence. No 17. Hook-shaped growth.

No. 18. Very brilliant mass, grouped above and running to a sharp point, in form suggesting a coral-polyp

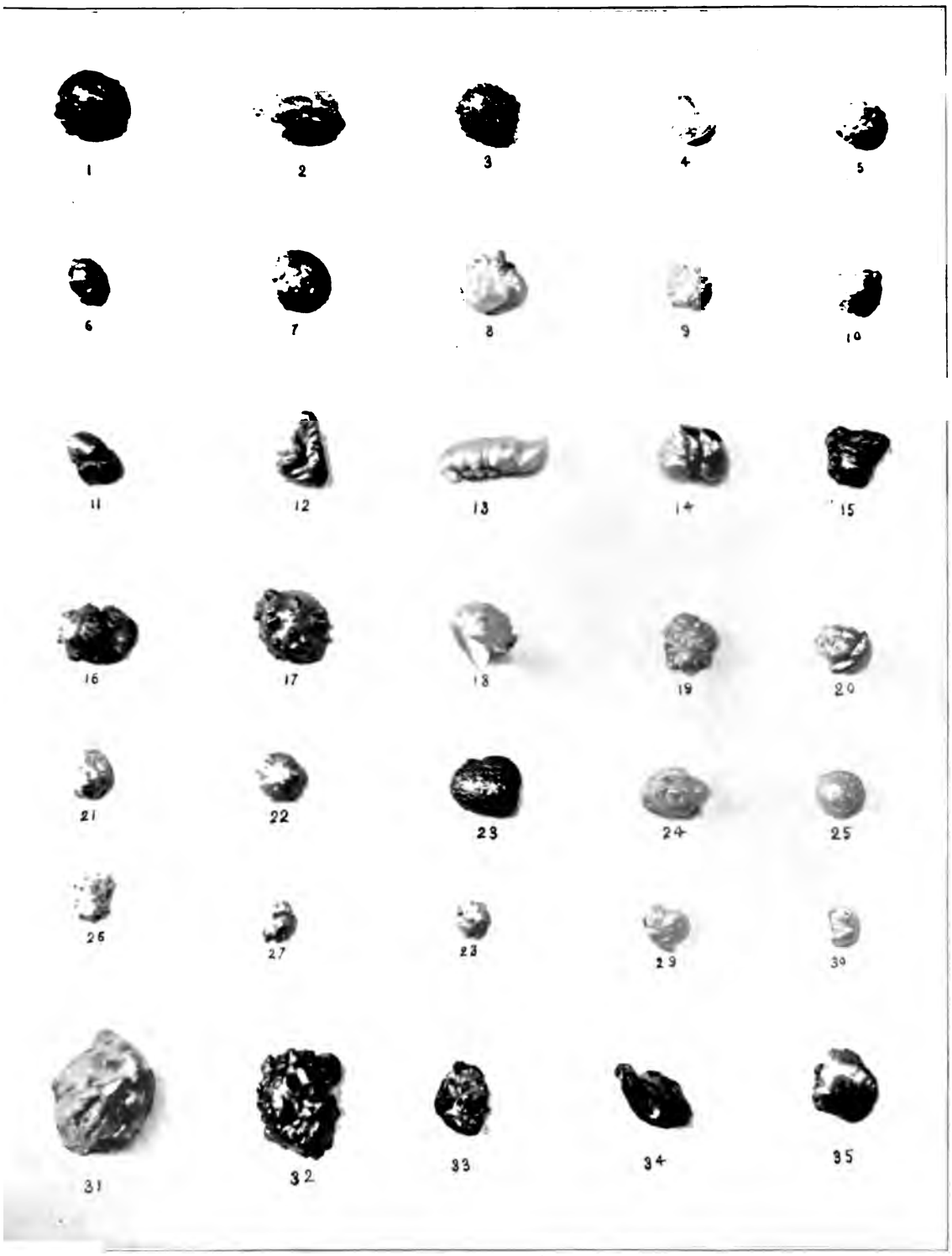
Group A.




Group B.

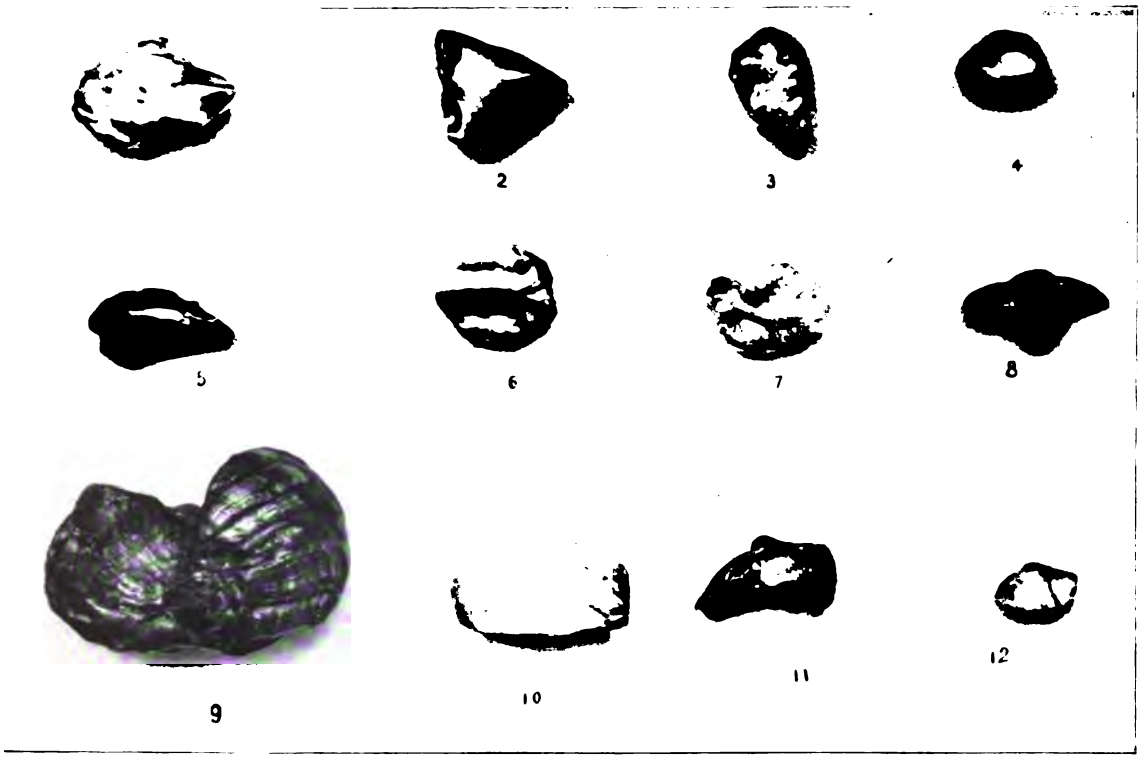
TWISTED, ELONGATED, AND OTHERWISE IRREGULAR PEARLS.

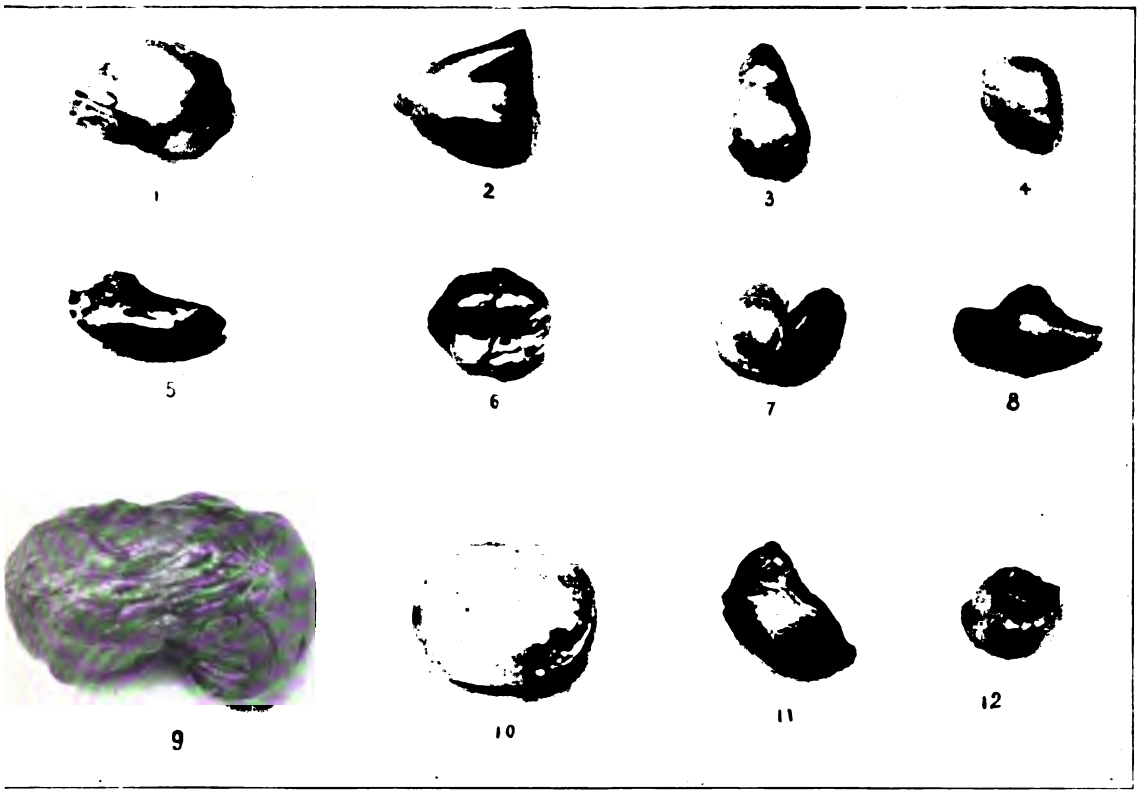
Those in Group B often very brilliant and highly colored; those in Group A white or paler. In Group A, fig. 6 almost triangular, and somewhat so in fig 13, with a sharp ridge above. Angular forms like these would suggest pebbles as nuclei.




IRREGULAR BAROQUE PEARLS.

Nos. 1-3, 5-10, 16-19, 23, 32, 33. Covered with small protuberances, prickly or warty.
Nos 11-15. Elongated, twisted, and flattened.
No. 31. Doubtless enclosing a large mass of foreign material, perhaps clay or a pebble.

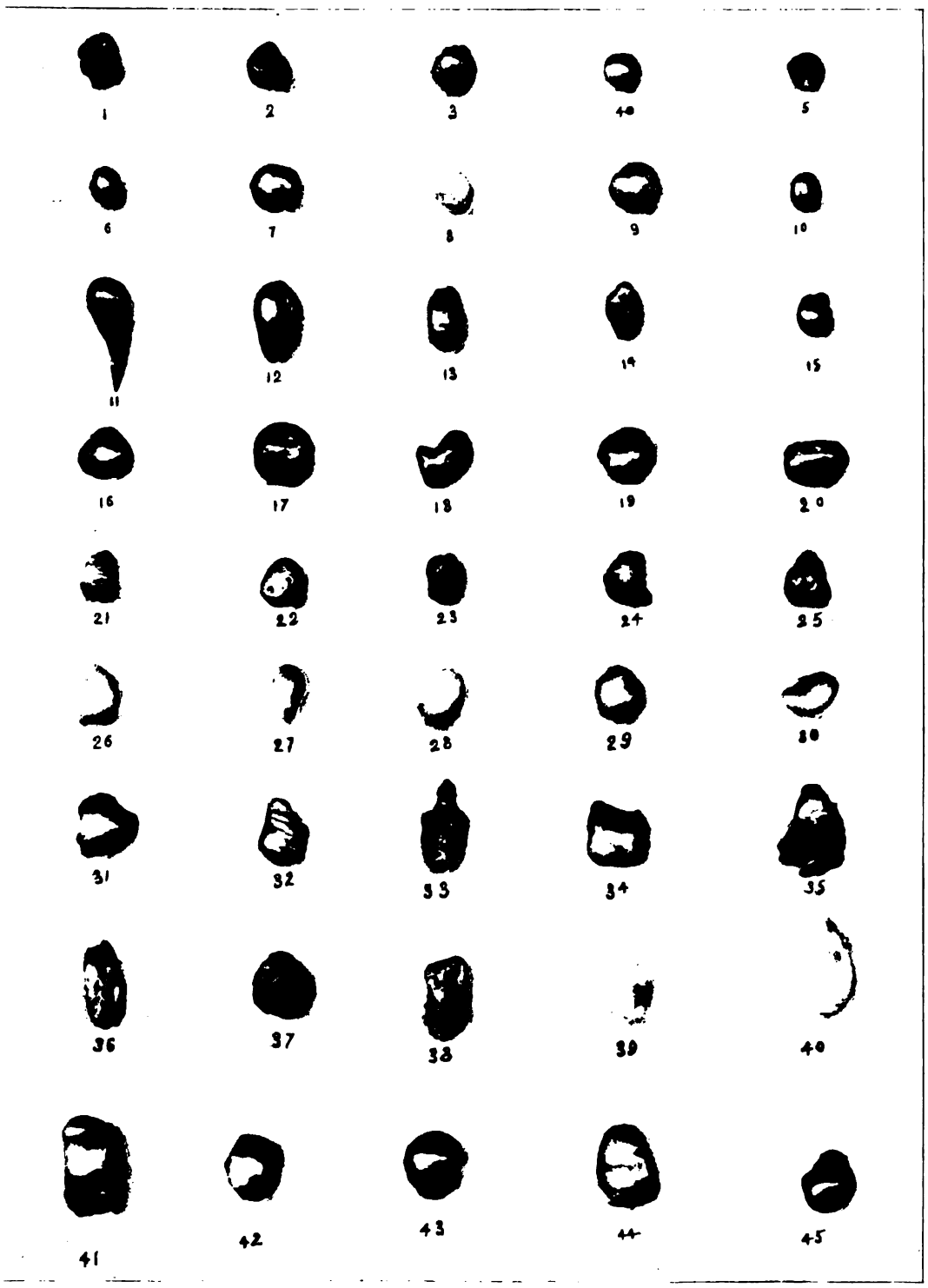



LARGE BAROQUE PEARLS: IRREGULAR NACREOUS GROWTHS, WITH MORE OR LESS BEAUTY OF LUSTER AND COLOR.

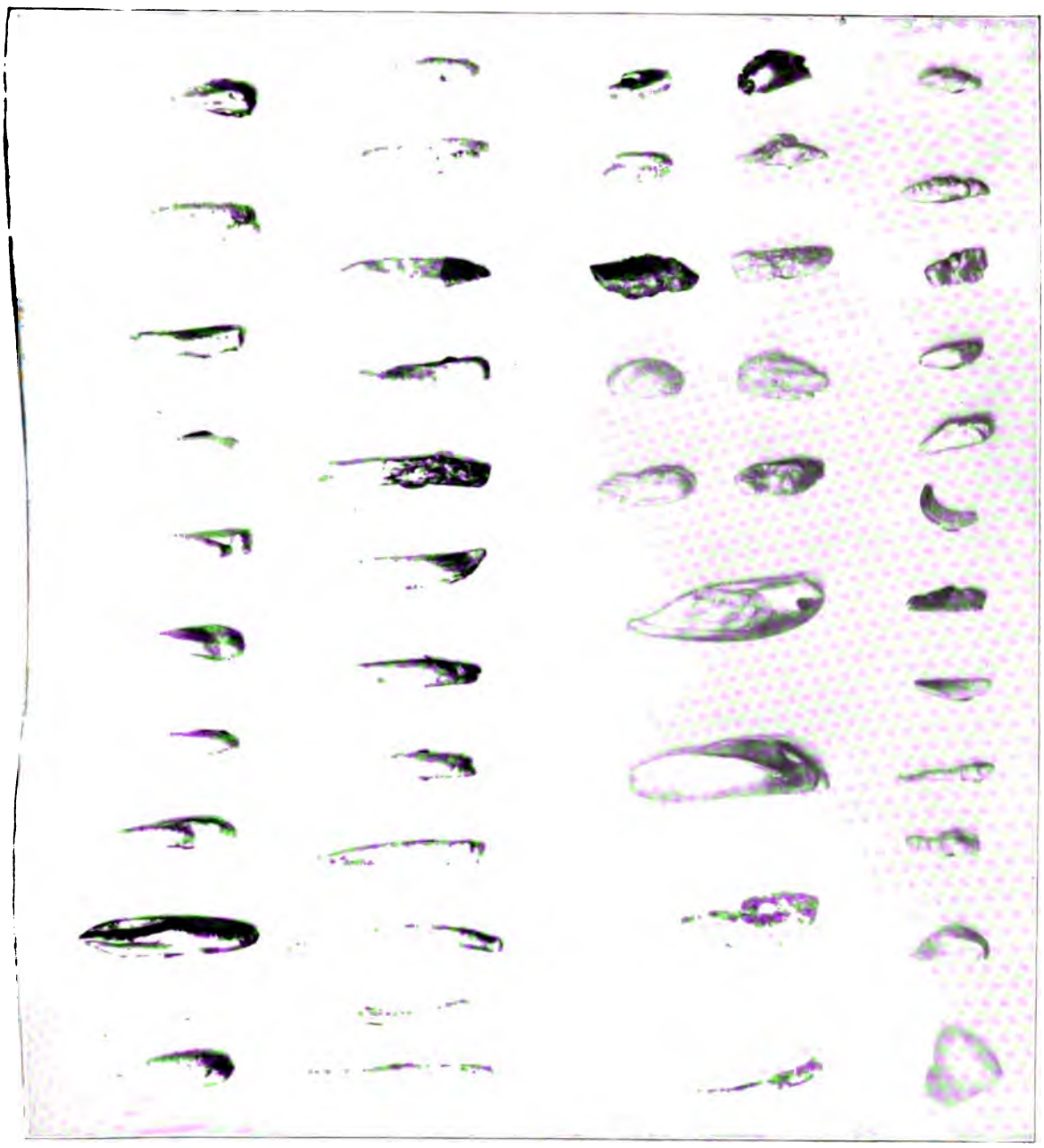
Nos. 1, 7, 8, 11. Showing a twisted structure.
Nos. 2, 3, 4, 6, 10. More regular.
No. 12. With a row of protuberances
No. 9. Immense mass of hinge-matter, salmon-pink in color.

The lower group is the reverse of upper group.



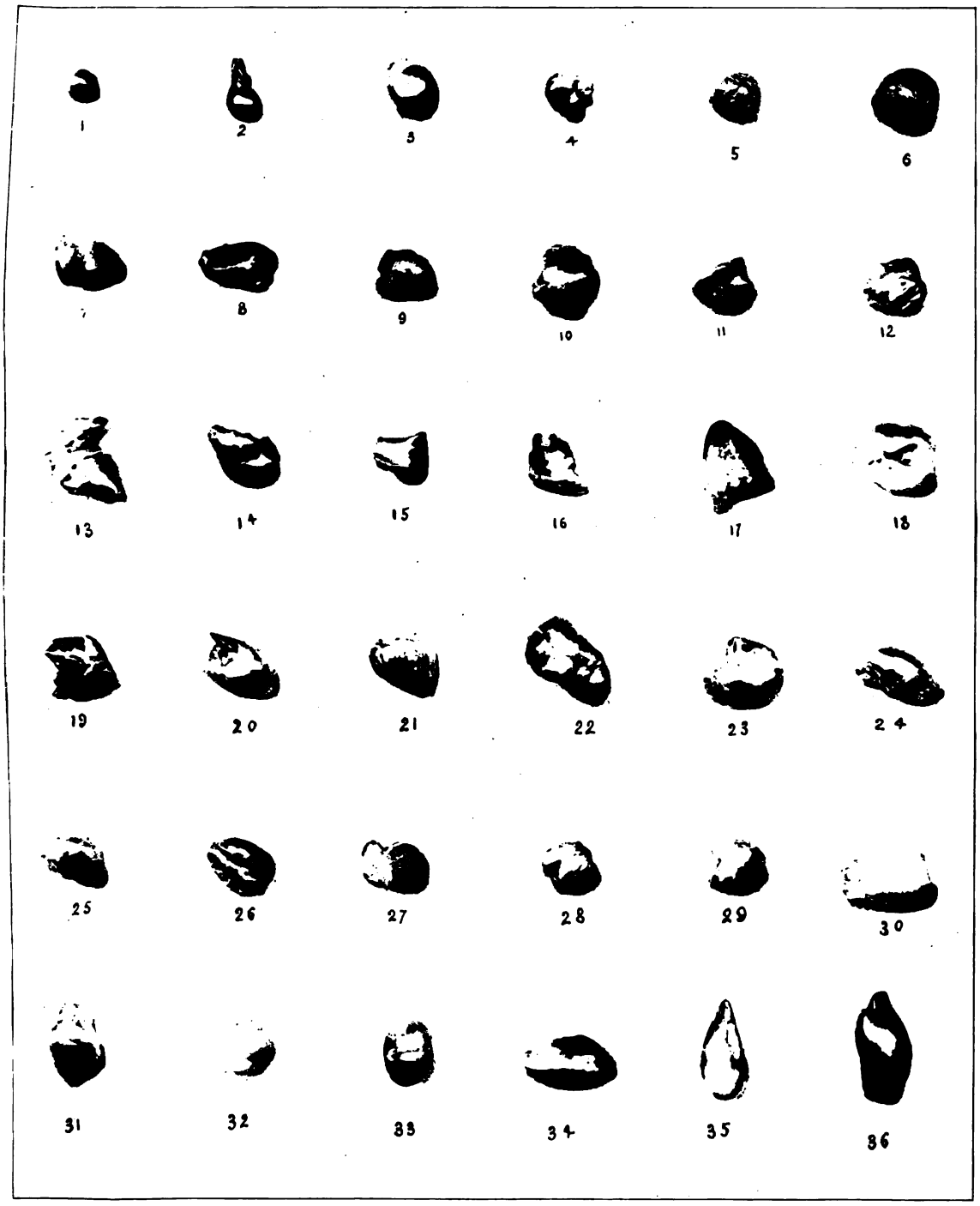

BAROQUE PEARLS.

Irregular and grouped pearls, occasionally drawn out like Prince Rupert's drop (fig. 11 and somewhat in fig. 12). The dark figures are rich bronze color in nature.



HINGE PEARLS.

Generally elongated, sometimes remarkably long and flattened, and suggesting various imitative forms, such as fishes, wings of birds and bats, winged seeds (samara) of maple and related trees, etc.




IRREGULAR AND TWISTED PEARLS.

Figs. 1-6, showing an inner (older) pearl, more or less covered, and enclosed by a secondary growth, the remaining figures showing peculiar twistings and irregular growths—Nos. 10-26, pustulate; Nos. 35, 36, elongated to a tapering point, etc.

REVERSE OF PLATE 21.

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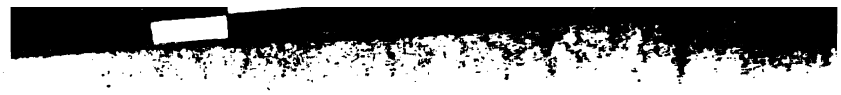
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